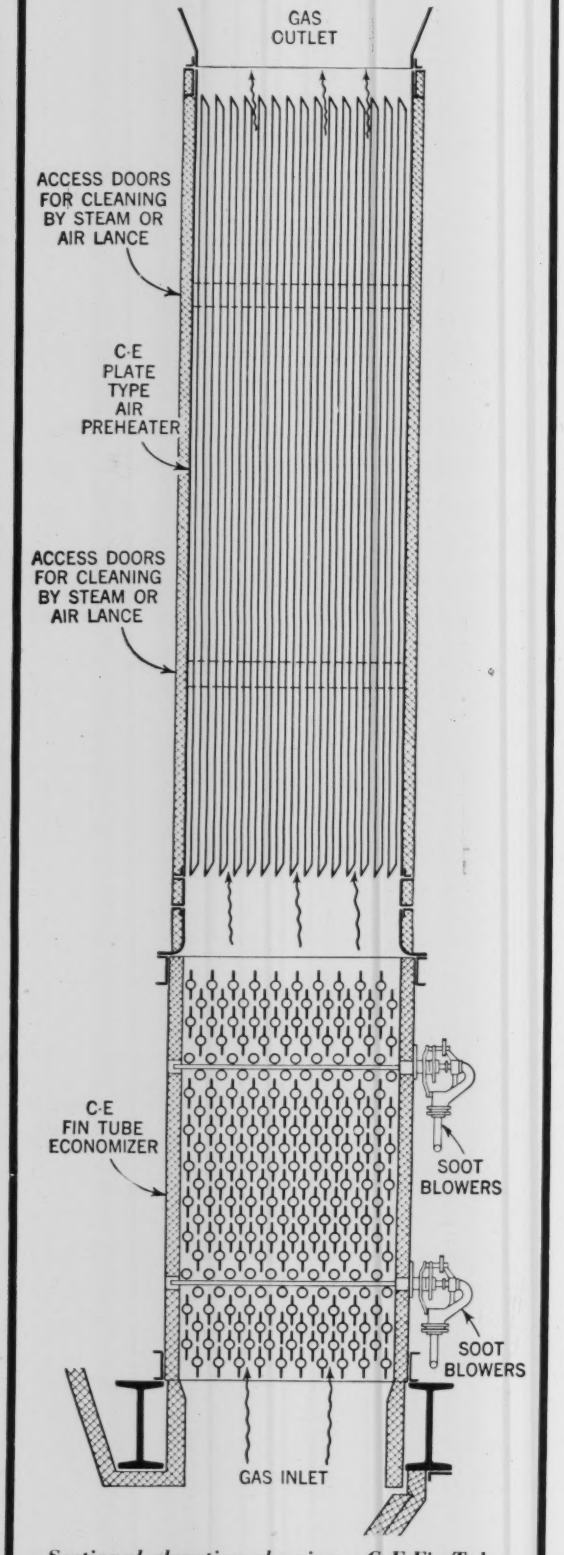
JUN 1 1931

MECHANICAL ENGINEERING

Cracks In
Thin Welded Metal

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

June 1931


GAS OUTLET
ACCESS DOORS FOR CLEANING BY STEAM OR AIR LANCE
C-E PLATE TYPE AIR PREHEATER
ACCESS DOORS FOR CLEANING BY STEAM OR AIR LANCE
C-E FIN TUBE ECONOMIZER
SOOT BLOWERS
SOOT BLOWERS
GAS INLET

Sectional elevation showing a C-E Fin Tube Economizer in series with a C-E Air Preheater

CIRCLE AT RIGHT shows gas flow through economizer fin-tube section

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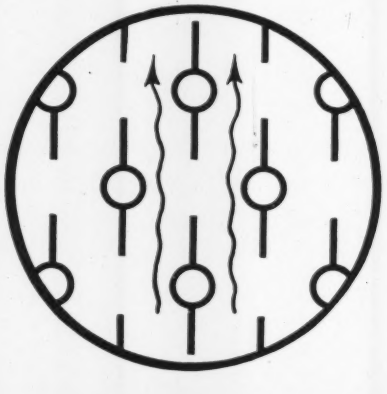

Mechanical Engineering

The Monthly Journal Published by
The American Society of Mechanical Engineers

Publication Office, 20th and Northampton Streets, Easton, Pa. Editorial and Advertising Departments at the Headquarters of the Society, 29 West Thirty-Ninth Street, New York
(Cable Address, "Dynamic," New York)

Vol. 53 June, 1931 Number 6

CONTENTS OF THIS ISSUE

Modern Textile Machinery — *Albert Palmer* — 411
The Wealth of Nations — *W. R. Ingalls* — 416
Development of the High-Speed Oil Engine in England — *A. F. L. Chorlton* — 421
Development of Anti-Aircraft Materiel — *G. M. Wells* — 427
The Cause and Prevention of Heat Cracks in Aircraft Welding — *H. S. George* — 433
Testing Dry Air Vacuum Pumps — *H. F. Mullikin* — 440
Economic Aspects of Industrial-Casualty Reduction — *L. W. Wallace* — 443
Revisions and Addenda to the Boiler Construction Code — 459
Rolled Threads for Screw Shells of Electric Sockets and Lamp Bases — 468
Conference on Industrial Relations — 471

DEPARTMENTAL

Survey of Engineering Progress — 447
A Review of Attainment in Mechanical Engineering and Related Fields
Work of A.S.M.E. Boiler Code Committee — 466
Engineering and Industrial Standardization — 469
Letter Symbols for Heat and Thermodynamics; Certification and Labeling; A.S.A. Appoints New Assistant Secretary; Local Representatives of A.S.A.; Prevention of Dust Explosions
Correspondence — 470
High-Pressure and High-Temperature Steam for Locomotives; Pneumatic Tubes
Editorial — 472
American Engineers in Russia; The Piece-Work System of Wages in Russia; Developments in Modern Elevators; The V.D.I. 75th Anniversary; German Research in Science and Engineering; Metals at High Temperature; Petroleum Mechanical Engineering; The National Industrial Congress
Book Reviews and Library Notes — 475
A.S.T.M. Standards; Industrial Evolution; Books Received in the Library
Synopses of A.S.M.E. Transactions Papers — 479
Current Mechanical Engineering Literature — 481

ADVERTISING

Display Advertisements — 1
Classified List of Mechanical Equipment — 34
Professional Engineering Service Section — 108
Opportunity Advertisements — 112
Alphabetical List of Advertisers — 114

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Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921.

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What It's All About

MODERN TEXTILE MACHINERY as the result of research and comprehensive engineering is discussed by Albert Palmer, research assistant to the general manager of the Crompton & Knowles Loom Works, in the June issue of MECHANICAL ENGINEERING. As in many other industries, interest in production in textile plants has been superseded by the necessity of developing products that customers will buy. New fabrics necessitate new machinery. Mr. Palmer writes on some of the engineering problems that this condition forces upon the manufacturer of textile machinery.

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"THE WEALTH OF NATIONS" was the title that Adam Smith gave to his classic work on political economy, from which have developed many of our economic concepts. Adam Smith and James Watt were contemporaries, and with them began the great industrial revolution. Since that time engineering has wrought increasingly greater changes in industrial and economic life, and to engineers the fundamentals of economics have become of growing importance. The present world-wide economic and industrial crisis gives especial point to the article in the June issue of MECHANICAL ENGINEERING that its author, Walter Renton Ingalls, Director, American Bureau of Metal Statistics, calls by the title Adam Smith made famous.

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HIGH-SPEED OIL-ENGINE DEVELOPMENT in England has an especial interest because engines of this type were used in the great airship *R-101*. In the June issue of MECHANICAL ENGINEERING, Alan E. L. Chorlton, consulting engineer, of London, who has been intimately connected with the beginning and evolution of the fast-running injection-type oil engine in England from the period of the Great War, writes on this subject.

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HEAT CRACKS IN AIRCRAFT WELDING where light-weight and thin-gaged metals are used are identical in nature with those that sometimes occur in steel castings. Foundrymen with many years of experience have cooperated with designers in avoiding cracks, but welders deal with a newer technology. In a paper on "The Cause and Prevention of Heat Cracks in Aircraft Welding," H. S. George, of the Union Carbide and Carbon Research Laboratories, in the June issue of MECHANICAL ENGINEERING, reports on a study of the forces that are likely to be met with in welding. Cracks fall into two groups, edge cracks and those caused by internally stressed metal.

:: :: ::

ANTI-AIRCRAFT MATÉRIEL represents one of the most important military developments carried on by the War Department as a result of the World War. In an article in the June issue of MECHANICAL ENGINEERING Capt. G. M. Wells, Ordnance Department, U.S.A., describes new types of anti-aircraft guns, and improved methods for directing their fire and locating and illuminating their target.

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TESTING DRY AIR VACUUM PUMPS presents a difficult problem because it involves the measurement of the exact amounts of air handled and steam consumed. In a paper on this subject in the June issue of MECHANICAL ENGINEERING, Harwood F. Mullikin, of The Johns Hopkins University, describes a laboratory method by which the conditions existing in condenser practice are met and results showing the characteristics of air pumps are obtained.

:: :: ::

ECONOMIC ASPECTS OF ACCIDENT PREVENTION are every bit as great as social ones, and frequently present more telling arguments. Every interruption of the routine that represents the "one best way" of any industrial procedure, contends L. W. Wallace, in an article on "Economic Aspects of Industrial-Casualty Reduction," in the June issue of MECHANICAL ENGINEERING, results in loss. Losses from non-personal-injury accidents may exceed those where some one is injured. It is important, therefore, to ascertain the causes of such accidents and to remove them, as they result not only in economic loss but represent potential human hazards.

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FUSION WELDING OF PRESSURE VESSELS has attracted much attention since the technology of this method of construction has been developed. The A.S.M.E. Boiler Code Committee presents in the June issue of MECHANICAL ENGINEERING revisions in its rules for the fusion process of welding, published in the December, 1930, and March, 1931, issues under the heading "Proposed Specifications for Fusion Welding." The Boiler Code Committee's rules are an important contribution to pressure-vessel construction practices.

MECHANICAL ENGINEERING

Volume 53 June, 1931 No. 6

Modern Textile Machinery

Standardized Looms Producing a Wide Variety of Fabrics and Developed as a Result of Cost Analyses, Save 34 Per Cent in Cost of Weaving, Reduce Second-Quality Yardage 50 Per Cent, and Increase Output per Loom 11 Per Cent Over Old Single-Fabric Machines

By ALBERT PALMER,[1] WORCESTER, MASS.

THE condition of business during the past few years has forced the industrial world to turn from the activities of production to those of study and development. Manufacturers, hitherto engaged in making products for which there was a demand, suddenly found themselves looking for customers. No one wanted more products of the conventional design. New and different things were needed to satisfy new requirements.

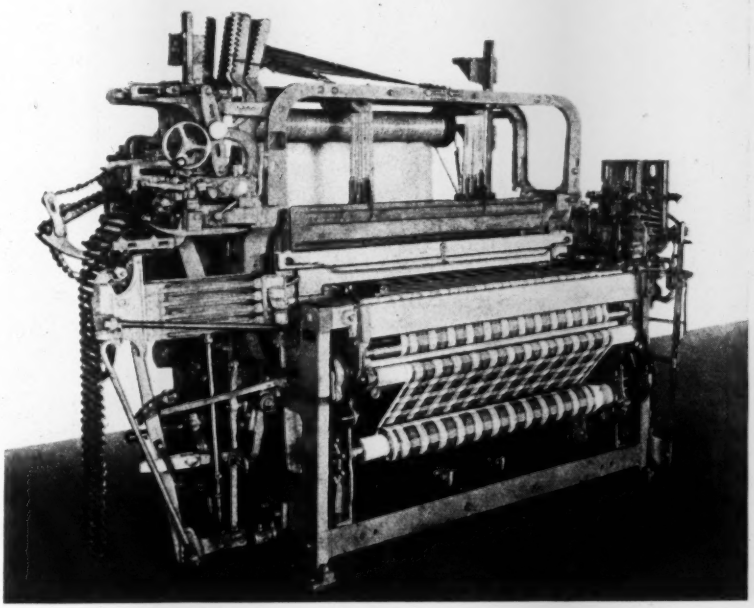

FIG. 1 AUTOMATIC DOBBY LOOM

The textile industry, including both the mills and the manufacturers of mill equipment, is probably the best example of an industry in which this change is taking place. For years it prospered from a trade in certain conventional products. One section of the cotton textile industry, for instance, conducted a very profitable business in ginghams. Beginning with 1868, the business as reflected in the number of gingham looms built, grew until the year 1928. Records show that in the 60 years from 1868 to 1928 a few more than 62,000 looms were installed. In 1925 the business began to fall off and decreased rapidly, until in 1928 not a single new machine of the type in question was produced. The gingham industry, for the present at least, is a thing of the past. Its product has virtually been displaced by other fabrics in the manufacture of which its machinery is practically useless. The result is that the mills which were engaged in this section of the cotton textile industry either have reorganized their methods and equipment or have gone out of business.

To an industrial world in which the strides of progress have been great, the backwardness of the textile mills in buying improved machinery has been incomprehensible. In consequence both the builders and the users of mill equipment have been criticized severely by those who are familiar with other industries. Measured by the replacement policies of other industries the progress of the textile industry has been slow. But that slowness has had some justification. Textile machinery is peculiar in that its individual units are not independent. Each unit is a part of an operating

[1] Research Assistant to General Manager, Crompton & Knowles Loom Works. Jun. A.S.M.E. Mr. Palmer was graduated in 1920 from Harvard College with the degree of S.B., and from the Harvard Engineering School in 1923 with the degree of B.S. in Mechanical Engineering and Business Administration. The following year he studied at the School of Technology, Victoria University, Manchester, England, as Sheldon Fellow of Engineering from Harvard University, and in 1924 made an investigation of the textile-machinery industry in the principal European countries. He then formed his present association, and has since been engaged in problems of research and development in the manufacture of textile machinery.

Contributed by the Textile Division for presentation at the Hartford, Conn., Meeting, June 1-3, 1931, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Abridged.

chain, the links of which are held together by auxiliary equipment, such as bobbins and warp beams, which is used to convey the product from one machine to the next. A radical change in one unit affects some, if not all, of the others. This situation has delayed the adoption of new ideas.

The advantage of uniformity, too, has been a deterrent to the use of new machinery. When a mill enlarged its weaving department it bought machines like those which it already had. This practice simplified the problems of training the operatives, of working out the complicated pattern chains that are necessary, of scheduling production, and of stocking repair and supply parts.

With the changes that have taken place recently, the attitude toward new developments has been altered. New fabrics necessitate the use of new machinery. Competition likewise, through the medium of production costs and quality, draws attention to the possibility of improvement. An incentive to produce radically different machinery has therefore been created.

To satisfy the present and future needs of the mills, a new method of approach is being used by some of the textile-machinery builders. Trained men are being sent out to study the equipment under operating conditions. The efforts of these investigators are directed toward a thorough understanding of the three problems which concern the manufacturing departments of the textile industry: namely, those that relate to low cost, high quality, and quick deliveries.

In the loom-building industry the research work started with a study of cotton mills. First the scope of the field was studied from the angle of production costs. Although in a great many mills the cost analyses were found to be very inadequate, they were good enough to show that more detailed investigation would yield important results. The preliminary reports indicated that the cost of a yard of cloth could be divided approximately as given in the two examples of Table 1.

TABLE 1 CONSTITUENTS OF COST IN TYPICAL COTTON FABRICS

Item of cost	Per cent of total mfg. cost		Per cent of process cost	
	Case 1	Case 2	Case 1	Case 2
Cotton	26	31	...	...
Making yarn	29	31	39	45
Weaving	41	25	56	36
Finishing	4	13	5	19
Total	100	100	100	100

These figures showed that the weaving cost represents a substantial part of the cost of manufacturing a yard of cotton fabric. Accordingly consideration was given to the fundamentals of the problem of reducing weaving cost.

COST FUNDAMENTALS

In a weave room, cost finding is relatively simple if the matter is treated on the machine basis. But two items are needed—the cost of running the machine during a given period of time, and the number of yards produced by the machine during the same period. From these figures the cost per yard can be obtained by dividing the former by the latter.

To find the cost of running a loom over any period of time, such as a week, is not a very difficult matter, provided the elements of cost are appreciated. In consisting of the cost of direct labor, indirect labor, and overhead, they are no different from any other manufacturing costs. For the purposes of illustration an example taken from the cases that were studied gives the cost per loom per week as follows:

	Cost per loom per week	Per cent of total
Direct labor	$3.65	52.9
Indirect labor	0.85	12.3
Overhead	2.40	34.8
	$6.90	100.0

With this information before him, the machinery manufacturer was able at once to see the greatest possibilities for improvement. Obviously they lay in direct labor and overhead. Of the former, all the component items were susceptible to improvement. Of the latter, repairs and supplies, and taxes, depreciation, and insurance on the machinery offered similar opportunities.

COST REDUCTION

In the case of direct labor, the cost could be decreased by reducing the amount of work which each loom required of the weaver, the battery hand, and the loom fixer. Through such an accomplishment, each of the operatives could tend, with no more effort, a larger number of machines. Obviously, then, the next step was to find out how these workers spend their time. The procedure by which this work was done and the manner in which the findings were used to change the design of the looms will be treated later.

The overhead items are largely dependent upon the cost of the loom to the mill. If the price of the machine is low, the cost of taxes, depreciation, insurance, and supplies is also low. Similarly repair charges are minimized in equipment which is so ruggedly constructed that the adjustment and breakage of parts is infrequent, and which is so simple that repairs can be made readily where they are necessary. In other words, the problem of reducing overhead was one not only to be studied in the field, but also in the plant of the loom manufacturer. To analyze the work of the mill mechanics was not enough. The design of each part of the machine had to be examined from the viewpoint of cost, and had to be changed to make the fabrication of the part possible by the most modern methods.

A little thought reveals the fact that for a given fabric, the number of yards produced by a loom in a given period of time depends upon two elements:

1 The speed at which the machine runs, and
2 The percentage of the period of operation which represents actual running time.

Speed is clearly a function of construction. A loom which has parts that fail under the stresses of rapid movement must operate at a low speed. One that has strong parts can run at a high speed, provided it can handle gently the yarns of a delicate fabric. The question, then, of obtaining high speed was one of studying the action of the loom under high-speed conditions. A thorough knowledge of the weak points resulted.

Closely allied with the speed analysis was the investigation of the operating efficiency. To reduce the time lost through the adjustment and the repair of parts was one consideration. To eliminate idle time arising through the automatic stopping of looms upon the breaking of a thread was another. Of the two the latter was found to be the more important, especially where the weaver was tending a large number of machines. A reduction in the rate of stoppage through changes in design decreased the amount of idle time for each machine, not only by diminishing the number of stops per machine, but also by lessening the possibility that more than one machine would stop at once.

METHODS OF ANALYSIS

The procedure for observing looms under operating conditions was planned very carefully. Preliminary

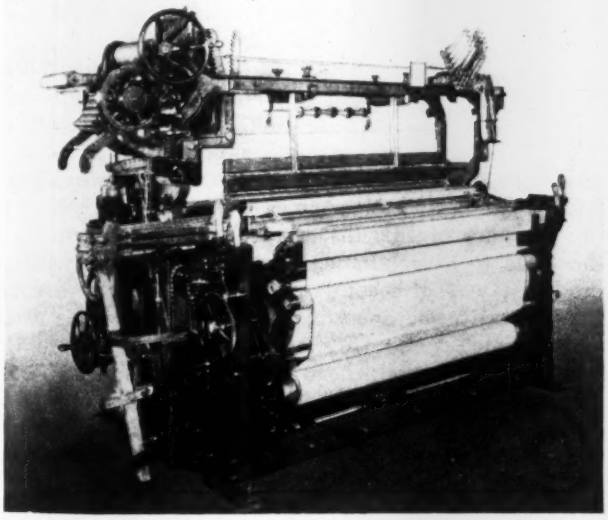

FIG. 2 NEW SILK LOOM

studies were made to determine the nature of the problem. Suitable equipment and a series of forms were developed, and an outline of standard practice was prepared so that the observations of the group of research men who went out would be made in a uniform manner. On the form used in making a loom study the observer follows the weaver whose set of looms he is studying, and records the time involved in every operation that is performed. He also keeps a record of any time that is lost during the test.

The information that is recorded is summarized at the end of the period of observation and is transferred to another form which is arranged so that a complete diagnosis of the case can be made. Under the heading "Summary of Loom Production," the capacity of the looms is accounted for. From these figures the main sources of lost time can be seen.

Another section of the form, entitled "Analysis of Loom Operations," provides a measure of the operating efficiency of both the machines and the operative. This information not only serves as the basis for corrective action, but also, with the figures of the suc-

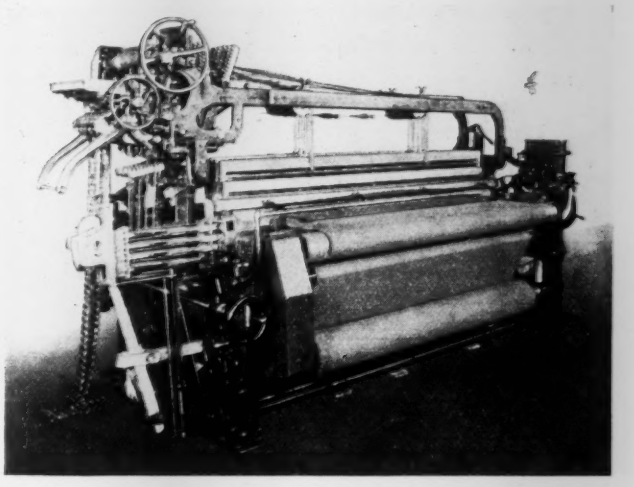

FIG. 3 NEW HIGH-SPEED AUTOMATIC WORSTED LOOM

ceeding section, "Analysis of Weaver's Time," provides a means for determining the number of looms that the weaver should operate.[2]

RESULTS OF OBSERVATIONS

The observations yielded information that pointed directly to a number of major problems. In the first place, the average productive efficiency in the mills where the studies were made was not much over 75 per cent. When consideration is given to the fact that the tests were made under the best existing conditions and that normally, because of warp changes and miscellaneous delays, the long-time efficiency of most mills is at least 10 per cent lower than this time-study efficiency, the situation is not commendable. That it results largely from a lack of balance between the work that the weaver is capable of doing and that demanded of him by the looms is clear when records show that in many instances the looms were idle, waiting for the attention of the weaver, during 15 per cent of the working day. This condition can be remedied only by giving the weaver less work,

[2] This matter is treated in an article by the author entitled "The Weaver-Loom Balance," which appeared in the *Textile World*, vol. 75, no. 11, Mar. 16, 1929. The procedure by which the information is compiled is described in two instalments of an article entitled "Establishing Yardsticks of Performance in the Weave Room," in the *Textile World*, vol. 79, nos. 15 and 16, April 11 and 18, 1931.

either by decreasing the number of looms tended or by decreasing the rate of stoppage per loom. Obviously in the interests of low cost the latter course is preferable.

An approach to the problem of reducing stoppage was made through an analysis of the test records. This study showed that approximately 85 per cent of the stoppage of an automatic cotton loom could be attributed to warp breakage, filling breakage at the transfer of the bobbin, and to other filling breakage.

Warp breakage, in addition to being of first importance because of the number of times it occurs, is of even greater moment when time is considered. From 60 to 75 per cent of the weaver's weaving time is devoted to the piecing of broken warp ends. Breakage of filling at the transfer of the bobbin takes about 6 per cent, and other filling breakage about 13 per cent.

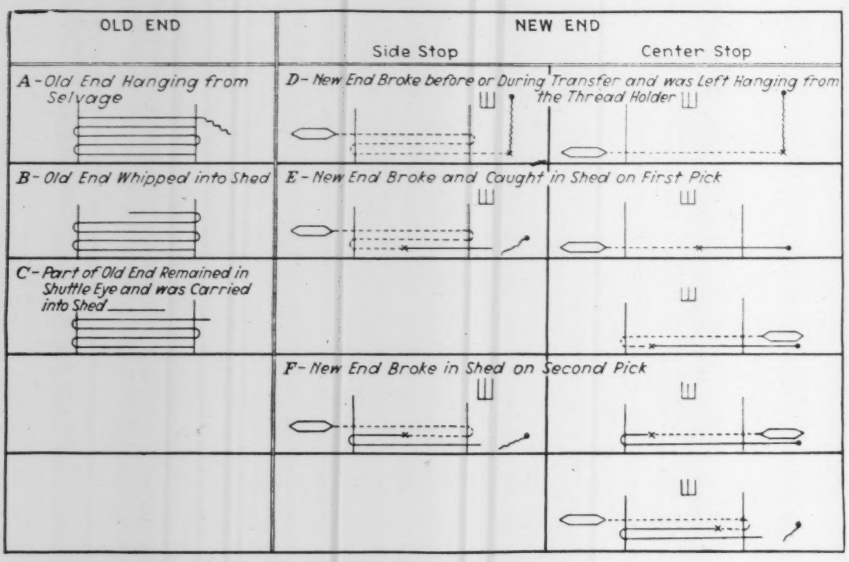
OLD END
NEW END
Side Stop
Center Stop
A - Old End Hanging from Selvage
D - New End Broke before or During Transfer and was Left Hanging from the Thread Holder
B - Old End Whipped into Shed
E - New End Broke and Caught in Shed on First Pick
C - Part of Old End Remained in Shuttle Eye and was Carried into Shed
F - New End Broke in Shed on Second Pick

FIG. 4 ANALYSIS OF FILLING BREAKAGE AT THE TRANSFER OF THE BOBBIN IN AN AUTOMATIC LOOM

All these difficulties were analyzed. In the case of warp breakage, for example, studies were made to determine the causes for the breaks. About a third could be traced to knots and slubs, but for the majority there was no immediate explanation. Accordingly the location of the breaks was studied. From the back to the front of the loom the average distribution was found to be as given in Table 2.

The results of a similar study of the distribution of the warp breaks from one selvage to the other showed that the greatest breakage is in the region of the harnesses and the reed near the selvages. This information led to improvements in the lay, the harness, and the picking motions.

Filling breakage was analyzed in a like manner. Both causes and locations were considered. Fig. 4, for instance, gives the common conditions in which both the outgoing and incoming ends of filling are found when the loom stops because of filling breakage at the transfer of a bobbin in an automatic loom.

TABLE 2 PERCENTAGE DISTRIBUTION OF WARP BREAKS IN COTTON LOOMS

Location	Gingham loom	Dobby loom
Beam	..	3
Whip roll	2	2
First lease rods	1	1
Warp stop	10	5
Second lease rods	21	10
Harnesses	46	63
Reed	19	15
Fell of cloth	1	1
Total	100	100

The information that resulted from this investigation led to numerous changes in the magazine, particularly in the bobbin giveways and in the thread holder, which greatly reduced this source of stoppage.

IMPROVEMENT OF QUALITY

Next to the cost of production, quality is of vital interest to the mills. While at one time the question of defective cloth may have been considered lightly, it no longer can be so regarded. Competition, the necessity of selling fabrics in a buyers' market, and modern methods of mass production in the clothing industry have imposed upon the textile industry nearly impossible standards of perfection. The cloth that is manufactured must be practically flawless.

The burden of maintaining a high standard of quality rests primarily on the mill. But the machinery manufacturer can be of invaluable service to the user of his equipment if he studies the inferior goods and determines what caused them. In the program of this discussion, men were sent into the mills to ascertain what percentage of the yardage produced was of second quality. Next they learned what constituted a second The defects were listed and were classified to show whether they were the fault of the material, the worker, or the loom. Those that were attributable to the loom were then analyzed.

A typical example of this work relates to the defects which are the result of ends of filling being drawn into the cloth in automatic looms. Analysis showed that any one of the six cases shown in Fig. 5 might occur. Of these No. 4 was found to be the most troublesome, principally because of the fact that it is something over which the mill has little or no control. To remedy this difficulty a great deal of experimental work was done under the direction of an ingenious inventor, with the result that the problem apparently has been solved.

QUICKER DELIVERIES

Not unlike the problem of quality, the third major item, namely, the question of quick deliveries, is one for which there is a dual responsibility. Here again the mill bears the major burden, but looks to the machine builder for assistance in lightening it. The

latter can do his share by providing machinery that is capable of

1 A high rate of production, and
2 A wide variety of uses.

The manner in which a high rate of production can be obtained has already been discussed in connection with the yardage to be had from a loom over a given period of time. The characteristic of flexibility in use, however, involves somewhat different considerations. Once more market conditions play a part. In the first place, the textile industry is at the mercy of style. Next, it is affected by seasonal changes. Lastly, it is faced with the necessity of adapting itself

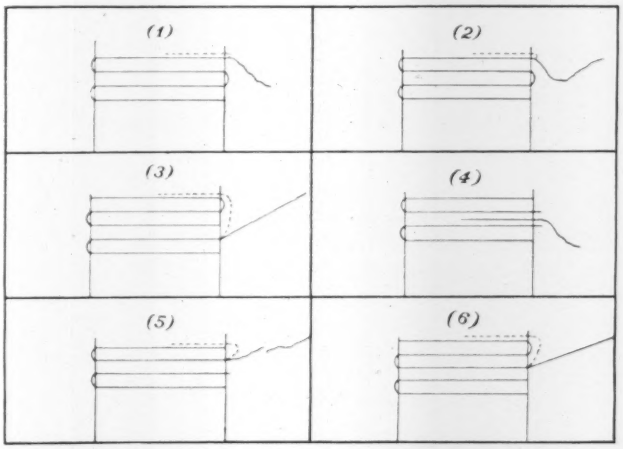

FIG. 5 ANALYSIS OF DRAWN-IN FILLING ENDS ON AN AUTOMATIC LOOM

(1) Old end not held by magazine thread cutter.
(2) Old end breaks between selvage and magazine thread cutter before temple cutter works.
(3) Old end goes over or under temple cutter.
(4) Old end remains in shuttle eye at transfer.
(5) New end breaks between selvage and thread holder before temple cutter works.
(6) New end goes over or under temple cutter.

to the manufacture of fabrics in which there is a greater profit than in those hitherto produced.

Under these circumstances, the desirability of a flexible loom is evident. The mill which is equipped with machinery that will produce a variety of fabrics has an immense advantage over the mill which can make but one or two. To be able to shift from a plain fabric to a fancy fabric, from a light fabric to a heavy fabric, or from a fabric of one material to one of an entirely different material, is a distinct asset. Furthermore, if the machinery can be changed quickly, by the addition of attachments, to weave a different line of goods, it enables the mill to go at once from an unprofitable line to a profitable one.

The looms that are used in the weaving of silk are a good example. Heretofore they were built on 16 different frames. Parts, generally speaking, were not interchangeable between the different models, and were not machined with sufficient precision to make those of any given model interchangeable without fitting and filing. Interchangeability could not be obtained because thorough machining was not possible. This situation existed for two reasons: First, because the parts were not designed in a manner such that modern machine tools could be used, and second, because the variety of parts rendered the use of expensive jigs and fixtures impossible under the existing scale of prices. In other words, a complete lack of standardization was an obstacle to giving the silk industry improved, flexible machinery at a price not exceeding or lower than that of the existing machinery.

To enable better machinery to be produced and sold at a lower price, a complete program of standardization was undertaken. There resulted:

1 One frame designed to serve as the base for the common models heretofore built on 12 different frames.

2 One group of parts arranged in the form of subassemblies constituting a series of mechanisms common to all models.

3 One group of parts arranged in the form of subassemblies, each of which is a mechanism peculiar to the construction of a given model.

Coincidently all parts were designed to make possible the use of modern foundry and machine-shop equipment in their manufacture. The result is that the framework and all the parts that are attached to it are machined in jigs and fixtures. The accuracy of the product combined with its standardized form renders not only individual parts but whole mechanisms interchangeable. A loom with plain bearings can be made into a roller-bearing loom by the substitution of roller for plain bearings. A non-automatic loom can be made automatic merely by the addition of a magazine. A loom equipped with one type of harness motion can be changed to do another type of work by an interchange of harness motions. Similarly, by minor substitutions, the lay can be converted from one box combination to another.

In the cotton and in the worsted fields similar progress has been made—in fact, as has been stated already, the first work of this sort was done in the former. The degree to which it has been successful is measured best by the results obtained in one of the several large installations of the new cotton loom.

1 In the cost of weaving a saving of 34 per cent has been made. The figures include all the items of labor and overhead mentioned earlier in this paper.

2 Second-quality yardage has been cut in half.

3 The average rate of production per loom is 11 per cent greater than that of the old machinery on the fabric that is being woven. In addition, the mill, now busy, on marquisettes, is in a position to alter its looms by the necessary attachments and to weave such fabrics as dress goods, fancy handkerchiefs, towels, rayon crepe, and even gingham, if it once more becomes marketable.

The conclusion to be drawn from these facts is that the new machinery shown in Figs. 1, 2, and 3 justifies the work that has been done, and demonstrates the efficacy of a combination of mill research and comprehensive engineering.[3]

[3] The machines shown in Figs. 1–3 are products of the Crompton and Knowles Loom Works.

The Wealth of Nations

With Especial Reference to the Part Possessed by the American People

By WALTER RENTON INGALLS,[1] NEW YORK, N. Y.

THE question of the wealth of nations may be approached effectively by thinking of the affairs of a family and considering that the affairs of the American people as a whole may be something similar multiplied by thirty million. The subject may be clarified by reviewing historically some one of its phases—for example, the early economic history of the colonization of Massachusetts.

The immigration which ran strongly from 1630 to 1639 brought to Massachusetts some of the most virile stock of England. The newcomers found the opportunity that they expected, the relative ease of their economy being evinced by the rapid multiplication of their families and their increase in wealth.

The farms, the forests, and the fisheries had it in them to supply all of the food, fiber, and fuel that was needful for sustenance, clothing, and heating. The forests also supplied the timber for habitations, while clay beds furnished the material for brick, oyster shells for lime, and the skins of animals could be tanned to leather. All of these trades were instituted forthwith. The great deficiences were cordage, soap, ammunition, and tools and implements, which last are generalized under the head of the metals, especially iron. They boldly essayed to make iron at Lynn, using bog ore, but the ore was scarce and poor.

They did not have any gold and silver for money and for currency they used musket balls, or more commonly wampum or shell, which was adopted from the Indians and was legal tender until 1661. They had no bank accounts. Their increase in wealth could only take physical expression, e.g., in land and houses, cattle, and other live stock, tools, clothing, and furniture. In that way the inventories of yeomen dying after twenty years in the new country were often substantial.

Land of Little Value in the Early Days

During the first two decades land was of little value. It was of value only as a place on which to live and to produce. John Humfrey, a promoter of the company, acquired an area of five square miles and ruined himself. A house, a windmill, or a boat, on the other hand, was real wealth. We look back 300 years and visualize this primitive colony creating wealth by the application of work to materials, painfully and slowly, but ever forging ahead. If they had had credit, which means the ability to borrow from abroad tools and implements, metal goods, and other commodities, they might have progressed more rapidly. Even after twenty years not half the farms had a plow.

Comparing this with Russia, we find that the Soviet régime, without any gold or any foreign credit worth mentioning, is creating internal wealth in the form of houses, mines, factories, railways, hydroelectric power plants, mechanized farms and forests out of work and materials, and that complaint is made of insufficient labor. The Russians are aiming to do in a few years and on a gigantic scale what we have done in three hundred years, which would be a preposterous comparison if allowance were not made for the advantage of three hundred years of science and engineering—and at least they are accomplishing something.

Antithetically we may turn contemporaneously from Russia to France. According to Prof. André Siegfried, the French are a nation of individualist peasants, artisans, bourgeois. If we accept his definition of "bourgeois" as "one who has reserves," it is evident to any observer in France that this represents a very large part of the nation. On any estimate of the national wealth and the national income, it must be obvious that the average of these reserves is relatively small. As though there were some inherent magic in the conception, it is the dream of millions of Frenchmen to acquire a small property, to build a small house, to own a small business, to amass a small private income.

It is the outcome of incredible toil, but it is clearly understood, both in individualistic France and in communistic Russia, that the creation of wealth springs from work.

Wealth Not Synonymous With Capital

The foregoing illustrations, historical and contemporary, are intended to elucidate a fundamental conception. Wealth is not synonymous with capital, which means the equipment wherewith to produce wealth; nor with credit, which means the ability to obtain loans, for which the security may be wealth; nor with money, which is the medium for the exchange of goods and services. With certain reservations, wealth is the possession of things, tangible or intangible, that are useful or prized, and is cumulatively the measure of the difference between production and consumption, subject to the subtraction of decay and destruction.

Bank accounts, deposits in savings banks, investments in life insurance, and some other things that are often cited as evidences of wealth are not so at all. They are rather evidences of credit by virtue of which wealth may be acquired, and so they may reflect something as to the distribution of wealth. Increase

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An address delivered before The Franklin Institute of the State of Pennsylvania, Philadelphia, Pa., March 18, 1931. Abridged to about one-third.

in savings-bank deposits does not necessarily imply that the nation is becoming richer, but may show that the position of the class of people that so entrusts its savings is improving. In an inventory of the national wealth the listing is confined to such entries as gold, real estate, cattle, mines, factories, railways, ships, stocks of goods. To these must be added our investments in other countries and the debts they owe us, less what we owe to them and their investments with us.

If a national accounting could be made every year, as every corporation is supposed to do with the assistance of an auditor, we should have an idea of how we stood in our national economy. There is, however, a real need for an engineer's review, as book credits may remain for property that has vanished or become valueless by obsolescence. The subject is a difficult one, and yet it has been possible at intervals to make more or less satisfactory estimates by broad deductions and generalizations. No excessive precision should be aimed at. In surveying a forest it is unwise to try to count the leaves, or even the trees.

Economists in other countries have estimated—occasionally, not regularly—their national wealth. The Canadian government makes such an estimate. German authorities have done it for their country, and Sir Josiah Stamp now and then makes an estimate for Great Britain.

By Act of Congress the Bureau of the Census was long ago directed to make a reckoning of the national wealth every ten years; this has been done and constitutes our only prolonged record in respect of this subject. However, it would be difficult to believe that the wealth of the American people increased from 1912 to 1922 to any such degree as appears from the Census figures, although such an increase has been made the subject of many serious conclusions. The trouble is largely with dollars.

Forms Which Wealth Takes

Wealth takes such forms as houses, railways, factories, etc. We may make periodic comparisons of such things, kind by kind, and come to a conclusion, for example, that we are having more or less floor space per family, or more or fewer automobiles. We cannot, however, add together farms, cattle, locomotives, automobiles, ships, etc., and get any reasonable total. In order to do that there must be a common denominator, and that can be only the dollar equivalent of each kind of thing. Obviously alteration in the exchange rate between dollars and things may disqualify a comparison of dollar totals for 1910, 1920, and 1930. We might of course obviate that by adopting arbitrarily a basic dollar, or rate of exchange, e.g., that of 1913, which is now commonly adopted as the base for the computation of indicia of prices. In fact the two conceptions would be precisely the same.

There is something to be said in favor of each expression of valuation, the 1913 dollar and the current dollar, which may be described alternatively as the physical or fiscal, or the basic and inflated. It would be better, however, if we were to compute our national wealth by using the dollar of 1913 as merely a common denominator to compound quantities and the current values to reflect contemporaneous positions. In respect of property there are several principles of valuation. In the case of capital goods, i.e., those that may be used for the production of wealth, there is a never-ending fluctuation in earning capacity as well as in the rate that is satisfying. On the other hand, there are some kinds of property as, for example, public utilities, on which the rate of return is limited by legislation or even governed by a fixing of price for the product. The estimation of national wealth on either a physical or fiscal basis is very difficult, and the two methods of estimation may give widely differing results.

Earning capacity is not the only determinator of wealth; e.g., the wealth of India consists largely of a hoard of silver, estimated at 7,000,000,000 ounces.

Estimates of National Wealth

In any estimate of national wealth, time is a highly important factor. This follows from the actuarial principle that a property whose earning capacity will not begin until after the lapse of 30 years has no present value. After that date interest charges consume the yield.

On the other hand, the actuarial principle is not entirely valid, or at least it is subject to qualifications. A deposit of iron ore that is useless until after thirty years may not have any present value in the capitalization of earning capacity, but the U. S. Steel Corporation, for example, expects to be doing business fifty years from now and rejoices that it possesses the ore reserves that insure its raw material for doing so.

The wealth of any country increases by the amount of its surplus of income over its living expense, i.e., its use of consumption goods; or oppositely decreases. Previous to the Great War the wealth of the American people increased above five billion dollars a year, which was about 15 per cent of our income. This was expressed chiefly in houses and railways. Since the war our income has been increasing in terms of dollars partly by virtue of increased population and increased productivity per man, and partly by expression in inflated dollars. On the other hand, our living expense has increased by virtue of more desires, and it is doubtful if our percentage of saving has been as high as formerly.

The expression of our savings has also experienced a change. We have put proportionately less into houses and railways and more into public utilities, into new forms of production (such as petroleum and automobile manufacturing), and into foreign investments. The aggregate of the last has risen to about 17.5 billion dollars, against about 10 billion at the end of 1920.

I have elsewhere referred to my estimate of an internal wealth of 273 billion at the end of 1920, in terms of dollars of 1913, and of the substantial agree-

ment of the subsequent Census estimate for 1922, when reduced to the same basis. In the nine years ending with 1929 the national income was about 364 billion in terms of 1913 dollars. If I estimate a national saving of 10 per cent, which may be outside rather than inside, the internal national wealth at the end of 1929 may have been about 310 billion. To convert into contemporaneous dollars multiply by 1.7 for 1921 and by 1.8 for 1929, thus obtaining totals of about 464 billion and 558 billion, respectively. So you see if you take 230 billion in 1912 as a starting point it makes an enormous difference whether my physical figure of 310 for 1929 or my inflated figure of 558 for the same year be used for comparison.

Of course you must recognize that my estimates for 1929 are but rough. The quantity of our national income is fairly well demonstrated. As to it there have been annual estimates by the National Bureau of Economic Research, the National Industrial Conference Board, and myself for a long series of years, each employing a different method, and we have been in remarkable agreement until recently. I am now using the arithmetical mean of these three estimates. In respect of the scale of general price level, which is represented by the factors 1.7 and 1.8, there is substantial agreement between Mr. Carl Snyder and myself. My reckoning of the percentage of annual saving is purely a guess.

I suppose a reasonable estimate of our national wealth at the present time is somewhere between 310 and 558 billion. That is a wide range, and we may narrow it in a guess of 400 to 450, but that is only a guess.

Effects of the Recent Economic Crisis

The slump in stocks, beginning in 1929, had nothing to do with the quantity of our physical possessions, which probably have continued to increase, although doubtless at a diminished rate in 1930. Also is it improbable that the American people suffered any such shrinkage in their wealth as 75 billion dollars, or 50 or 25. The investor who owned a share of stock worth 100 in 1927 may have seen it quoted at $200 in 1929 and again at $100 in 1930. If he sold at $200 he may have put the proceeds into a share of something else, or he may have done something different. For every buyer at the high prices there must have been a seller, and oppositely at the low prices of 1930.

This is far from leading up to the expression of opinion that the decline in the stock market was an affair of no economic moment. Quite the contrary. It shook our credit structure, forced liquidations, and produced sweeping changes in ownership. The trail of commercial insolvencies and bank failures is sufficient evidence of the passage of a hurricane. Eliminating the credit constraint, we are reduced to an association with wealth in only three ways, viz.:

1 In so far as liquidation of securities at high prices, instead of being exchanged for other securities, was diverted to expenditure for consumption goods, thus diminishing savings. We know that this happened to a certain extent, but in comparison with our great aggregate of consumption it may not have been serious.

2 The abstraction of the tax gatherer, which comes largely to the same thing, and is more serious.

3 The possibility that liquidation represented property that itself had become diminished in value or was forecast as about to become so. This might follow from a change in the habits or the politics of peoples. For example, if the men of the world should decide that no longer were they going to shave, manifestly the capital invested in plants for the manufacture of razors and blades would cease to have value. Political and economic policies leading to strangulation of consumption would be of more far-reaching effect. Such events might be discounted in the selling of securities, producing a decline in security prices.

The increment to wealth is not the same every year and may be severely contracted, if not canceled, in years of depression like 1921 and 1930. The diminishing of work, reflected in unemployment, in such years is *ipso facto* an evidence of restraint which conceivably may become subtractive. In the support of idle human beings who are no longer creating we cannot feed to them houses and locomotives, but we may allow such things as decay, without replacing them, and that comes to the same thing as if they were fed. This induces me to examine the causes of such a depression as occurred in 1930, our behavior during it, and its effect upon our national economy.

Since the end of the Great War there have been two great economic crises, viz., those of 1920–22 and 1929–31, which have been of world-wide incidence. In each of them there have been severe declines in commodity prices and high degrees of unemployment in industrial countries. The crisis of 1920–22 was more or less expected and was ascribed to a natural deflationary process. That of 1929–31 was less expected, and even after we were well into it there was imperfect appreciation of its nature and scope. The surprise and disappointment produced an unusual psychologic depression that in the course of time became rather hysterical and led many persons into behavior of fright and persuaded many others into making public statements contributing to fright.

It is not high wages that make prosperity, but it is prosperity that makes high wages. The maintenance of wage scales at which labor cannot find employment does no good to labor or to any one else. It does not increase buying. On the contrary, it is the curtailer of buying. The arbitrary maintenance of wage scales is price fixing just as much as attempts to maintain commodity prices, and one is just as strangling as the other. Municipal employment at fixed wage scales takes from taxpayers what they are unwilling to give privately.

Reasons Assigned for the Current Depression

The fact that numerous countries of the civilized world have been concurrently experiencing economic

depression indicates a common cause, although it is also to be recognized that a depression beginning in one country for causes peculiar to itself may, and probably will, have repercussions upon other countries, and so we may have the operation of a common factor, or of a special factor, or of both at the same time.

In the search for the basic ideas I have tried to classify the elementary opinions.

1 Shortage of gold, with worse to come on that account—not immediately, but as time wears on. This is the quantity theory of money in its baldness, and is strongly held by British financiers and economists. Not so strongly by American. This hypothesis has been controversial among economists for three centuries, during which time the negative has strengthened rather than the affirmative.

2 Maladjustment of gold supplies. This, which is more or less a sub-head, is also a British obsession. Thus, Lord d'Abernon, with this in mind, declared recently that the present depression could be cured in short order by bankers if they would. There are not many who agree with him.

3 The external war debts. The accrual of these mainly to the United States of America and the restrictions imposed upon the importation of goods into the United States are of adverse influence upon international trade. Some great leaders, like Mr. A. H. Wiggin, the scholarly head of the Chase Bank, regard this as so adverse that the United States ought further to abate or even to cancel the indebtedness to us for the sake of our own welfare. There is contrary opinion. I do not see in this situation a fundamental cause for the economic depression, but it may be an aggravation.

4 Breaking down of the capitalistic, or individualistic, system of economy in the face of the rise of the communistic. Those who express this opinion disregard the evidence that the individualistic system has certainly promoted civilization, while the communistic is still experimental and unproved.

5 Misconception of the nature of wages. This is an attempt to generalize the opinion that the people of depressed countries have lost the idea of working to earn in the futile conviction of working only for a stipend.[2] This is of course the old economic fallacy of a wage fund. In the opposite belief there is plenty of work to be done if the workers are willing. This opinion is expressed by some British publicists, Lord Inchcape for one, and by many Americans, who tersely describe our recent situation as a buyers' strike. Willingness on the part of workers is not, however, the only requisite. There is also need for direction of them. The absence of broad direction, which implies planning, may be a reason why the communistic system of Russia is being misconceived as an improvement upon the individualist economy of the rest of the world.

6 Decay of the principle of authority. This means that pure democracy is bound to make a mess of things, out of ignorance and inability to understand, to agree, or to act. This was lucidly analyzed and explained by Mallock in his "Limits of Pure Democracy." For the same reasons several countries of Europe have had to resort to dictatorships, with even Germany approaching closely thereto, in order to avert complete disaster.

7 Inevitability. In this opinion depressions are the natural corollaries of surges, and both are the consequences of miscalculation which in a complex economy cannot be avoided. In other words, prosperity entrains its own penalty, for which the thrifty will prepare while the unthrifty will alternate between joyousness and suffering.

I am offering these explanations as I derive them from reading contemporaneous opinions. I may point out, of course, that there is a certain association between the fifth and sixth, and even the seventh, heads; and that the fourth is very much in the nature of an admission of them. Communism, in the Russian experiment, abolishes the wage-fund fallacy and decrees working to earn, establishes the principle of authority as never before, and aims to squash the inevitability of industrial cycles by avoiding all miscalculation. Even now there is no unemployment in Russia, but neither is there any in China, where every one has to toil in order to keep alive.

The discontent with the existing working of things is not confined to the proletariat, but extends to other important classes. It may be described as the complaint of the small men—farmers, tradesmen, and merchants—who are being squeezed by the improved efficiency of competitors. This is perhaps the greatest dislocation of what is commonly called "mass production," which may be extended to include mass distribution. This produces results that inspire paradoxical emotions. The public prays for the cheap wheat of the mechanized farm and the cheap distribution of goods by the chain store, but objurgates the elimination of labor, whether proletariat or proprietary, that makes them cheap; and endeavors to get even by governmental operation and ownership which do not eliminate any labor and make things cheap only at the expense of taxpayers.

This kind of popular discontent is not assuaged by the production of any evidence of the general distribution of wealth and the enjoyment of the proceeds of efficiency by millions of stockholders, representation of which is a waste of time. It is directed against the intelligence that energizes the corporations, that is, management, which is popularly generalized as "Wall Street."

Overproduction Only in Unbalanced Production

The thesis of my lecture is that wealth grows out of work and thrift. Another expression of this is income and savings.

[2] My generalization under this head is so broad that I may fail to be understood. I mean that wages are fundamentally a measure of exchange of services. It is upon this that hangs the present controversy over maintenance or reduction of wage scales. It is obscure that while the employer may dispense wages in currency in an envelope, it is, in the final analysis, the consumer who pays them, and that the payment is in exchange of one kind of service for another.

There can be overproduction of some things, of foodstuffs, for example, for a population that enjoys enough thereof to be reasonably fat cannot eat any more, anyway ought not to try. On the other hand, there is no limit to the comforts and luxuries that a people may want and can have by working for them. Throughout our economic history the natural increase in the number of workers, plus all of the machinery that we have been able to contrive, has been absorbed in building railways, highways, bridges, and skyscrapers; in providing us with sewing machines, automobiles, and electrification in a myriad of ways. We should have been backward in our civilization if we had not the men, plus machinery, in order to do such things. How else would the Panama Canal have been built, or would New York have had its water supply, and Chicago its drainage? There is no reason to suppose that future conditions are going to be otherwise.

All of the present talk of mass production, overmechanization, and technological unemployment is one of the most vicious of the fallacious conceptions that afflict us. Pursuance of such conceptions leads not to wealth but to poverty.

What is called mass production or machine productions means economical production, i.e., production with the minimum labor. Instead of such a movement being contributory to crisis, it is crisis itself that intensifies or produces the movement. A management engaged in the production of a commodity and confronted by a falling price and a shrinking margin may require its men to reduce the labor component by accepting a lower wage, or it may inspire its engineers to improve methods so as to dispense with some men or so as to lead to more work and more production per man. If the operation is to survive, one of those things must be done in order to preserve work for anybody. If the men are unwilling to accept such alternatives, unemployment is bound to increase.

The Existing Unemployment Problem at Home and Abroad

In considering the existing unemployment in the United States it is important to inquire how much of it is ascribable to the wilfulness of workers themselves. Thus, on the eve of the depression in 1929, the building mechanics in my home territory raised their terms 10 per cent, and in 1930 they contemplated a further increase, with the explanation that if they were able to get work for only two days a week they would have to receive more per day. At the same time our dealers in anthracite raised their price a dollar a ton. This is obviously commercial thought upside down.

So it is that in the United States we have an appearance of overproduction, underconsumption, and unemployment at a time when we are nationally short of housing, when many homes are awaiting electrification, when many communities have no supply of running water, and when we have many acres of idle land, some of it in proximity to great cities, that is awaiting clearing, and many more acres, more remote, that ought to be reforested. We have the labor, the tools, and the credit with which to do such things, but under existing conditions we cannot afford to do them. We have been having a buyers' strike.

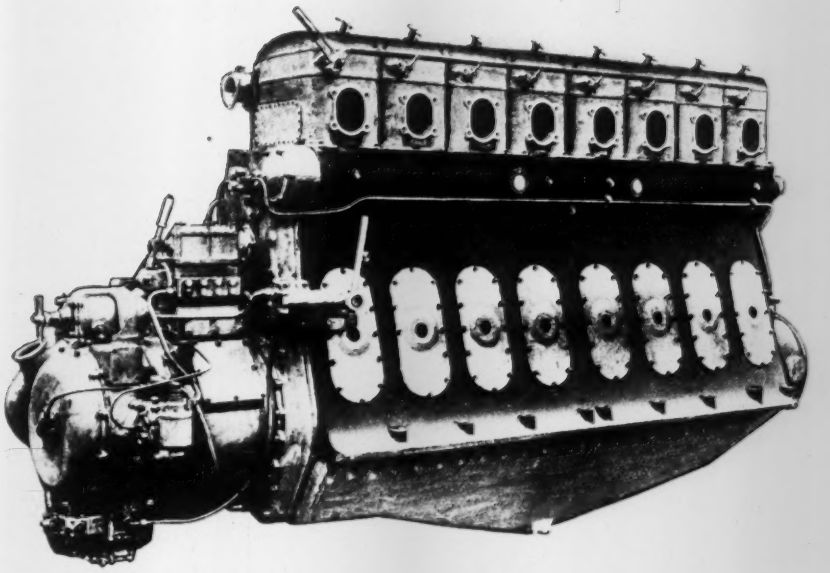
Surveying the situation in Europe, we discover similar conditions. Great Britain is short of housing, is in need of electrification, and ought to scrap and rebuild much of its manufacturing plants. Germany is even more short of housing. Both countries have idle men and plenty of material. Chancellor Bruening, at least, is endeavoring to stimulate domestic work for domestic needs.

Problem Not a Simple One

Please do not think me to be regarding the problem as being quite so simple as I have just been expressing it. Political acts play enormous parts. Great Britain, for example, debased its silver coinage, liquidated the silver release, and later by leading India toward the gold standard precipitated a decline in silver, depreciated the silver wealth of India, which is estimated at seven billion ounces, and upset the economy of China. As a consequence the Orient was able to buy less from Great Britain, and some of its chimneys ceased to smoke and collieries had diminished markets and colliers became idle. In every country the cost of government has risen, which means that more officials have to be supported by taxation. I am not shutting my eyes to any of these evils, but I am arguing that they are not inherent in capitalistic economy and that neither they nor what is called overproduction are evidences of breakdown.

But what about the workers who are permanently released by labor-saving economies? Eventually they will be absorbed into new occupations, as also the three-quarters of a million of new workers who every year are added to our number. The automobile industry, which in one way or another is supposed to engage about 10 per cent of all of our workers nonagricultural, was the great absorber during the last decade. During the next that will no longer be so, but by no means is our culture culminating with the automobile. Something new is going to come, leading to a higher scale of living. It may be through the solving of the secrets of chemistry and physics that our scientists are exploring in their laboratories. A retrospect of the last ten years makes us think that we are but on the threshold of a new era of applied science and that all available man power will be required.

In such interims, however, we should have means of utilizing all man power that is waiting, putting it to useful work, not building useless pyramids; but the man power itself should be cooperative and not assumptive of the position that the world owes it a living. This seems to me to be a broad generalization of our great problem. It means a reestablishment of the principle of the authority of intelligence, the loss of which has been the great misfortune of the world since the economic chaos of the ending of the Great War.



VIEW OF ENGINE DESIGNED FOR AIRSHIP "R-101," SHOWING ITS RUGGED CONSTRUCTION

Development of the High-Speed Oil Engine in England

The Story of the Inception and Evolution of the High-Speed Injection Type of Oil Engine From the Time of the Great War to the Launching of the "R-101," as Told by One Who Took a Conspicuous Part Therein

By ALAN E. L. CHORLTON,[1] LONDON, ENGLAND

THE author has been so intimately connected with the beginning and evolution of the fast-running injection-type oil engine in England from the period of the Great War up to the time of those installed on the airship *R-101*, that he thinks some notes on what was accomplished would not be out of place and might be of some assistance to others working in the same field.

It may occasion some surprise to engineers of 1931 to learn that the problem of the high-speed engine was so well considered by a limited number of engineers fifteen or more years ago, but it must not be overlooked that oil engines of many types had been made in Lincolnshire from the earliest days, that of the original patents Nos. 7,146 and 15,994 of 1890 of Akroyd Stuart being manufactured by Hornsby in a modified form in which the possibilities of the original patent were unfortunately lost sight of. Progress took place step by step, as it did in the gas engine, the compression being raised to secure greater economy, until by 1914 it had reached 300 lb. per sq. in.

The later engines differed from the original Akroyd (Fig. 1) only in having a higher compression, the same airless-injection system being used. (Fig. 2.) When the second patent for the turbulent combustion chamber (Fig. 3) expired, this principle came into very general use.

Practically no attention was paid by this school of designers to the work of Diesel, because at that time the Diesel engine as it was accepted, that is, with air blast, was not only heavy but comparatively slow-running.

One of the first engines to show the way to higher speeds was the Vickers, the type employed as standard for British submarines. These engines had cylinders $14^1/_2$ in. in diameter by 15 in. stroke, giving at a speed of 380 r.p.m. 100 b.hp. per cylinder, and were constructed in various aggregates up to 8 and even 12 cylinders in line. The detailed design was an advanced one, and afforded an excellent opportunity for mass production, which was taken advantage of at the beginning of the war.

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Presented at the Fifth National Meeting of the A.S.M.E. Aeronautic Division, Baltimore, Md., May 12 to 14, 1931. Abridged.

This engine is of the airless-injection type with an accumulator type of storage for the oil supply and one oil pump per cylinder; mechanically operated injection spray valves are used. The turbulence is the normal one arising from the speed of the air through the inlet valve without definite rotation. The common rail with one oil-pressure supply pump and timing valves was used later on some engines.

At this time the author was engaged in the manufacture of higher-compression oil engines, with the

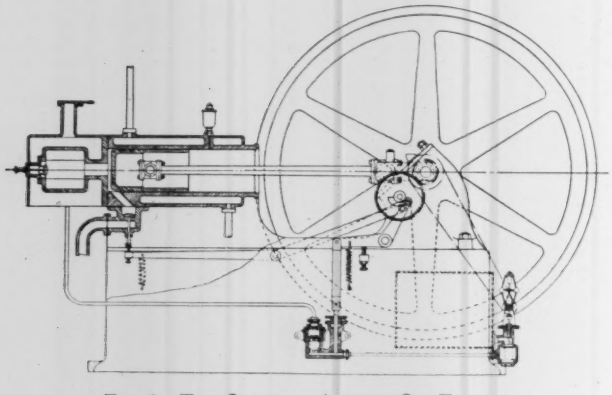

FIG. 1 THE ORIGINAL AKROYD OIL ENGINE

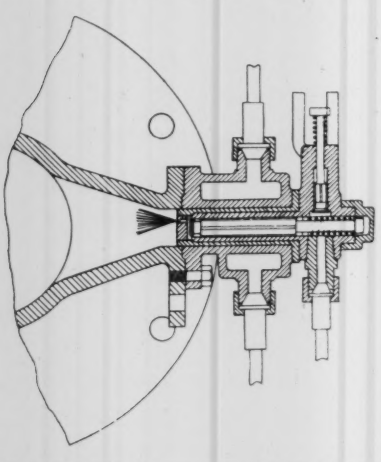

FIG. 2 AIRLESS-INJECTION SYSTEM OF ORIGINAL AKROYD ENGINE

turbulent combustion chamber of the Akroyd Stuart type, also employing solid or airless injection with automatic spray valves as the original engines did. There was also under him, in a separate part of the works, a department manufacturing four-cycle aero engines.

As the war went on, the demand for more powerful engines for submarines became urgent. To meet this demand the author submitted a proposal to the Board of Invention of the Admiralty (1915) using some of the parts of the standard submarine engine. In the design he did not overlook aero-engine practice, for the proposal was for an increase of 50 per cent in speed, the power per cylinder to rise accordingly.

In this engine (Fig. 4), to meet the higher speed and increased heat flow, an aluminum-alloy piston was used, the first large one to be made. This was cast in the foundry at Lincoln, of a mixture submitted by the author, though there was then but little experience, apart from air work, and that with but small diameters, 3 in. to 4 in., to go upon.

Though the lighter weight of the piston reduced the stress in the moving parts, these were replaced by others of high-value alloy steel as a precaution.

The valve area was at first not increased, the air speed rising accordingly, there being one inlet and one exhaust valve per cylinder; later, however, a common valve action was designed and tested. In this the same valves, i.e., both inlet and exhaust, were operated together, with a double-beat change-over valve behind them. The mechanical-injection valve was retained in all the earlier experiments. An automatic valve was fitted for some tests later.

At this time general-oil engine construction at the same works—Messrs. Rustons, of Lincoln—employed the turbulent combustion chamber. Fig. 5 indicates clearly the double-chamber or two-cell type, the tur-

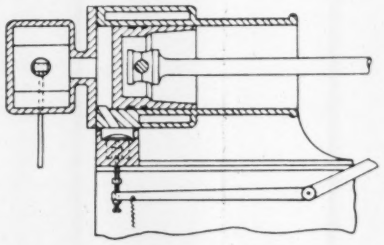

FIG. 3 TURBULENT-COMBUSTION CHAMBER, AKROYD ENGINE

bulent neck being between the two. Higher speeds than were possible with the normal inlet valve were used, and a better action in the chamber with reference to the spray could be arranged for.

As development went on the compression was raised, the turbulent chamber being step by step reduced in size.

The compression pressure in this engine was then 280 lb. per sq. in., the necessary auto-ignition being obtained by the heat of the uncooled chamber, as was done in all the hot-bulb engines throughout Europe descended from the Akroyd Stuart. The turbulent speed through the neck approached 400 ft. per sec.

These engines were economical, a consumption of below 0.45 lb. being obtained, and gave a clear exhaust.

The form of spray valve used was a single discharge hole with a whirling device set immediately in front of the hole. Fig. 6 shows the turbulent Akroyd Stuart head on this engine.

When it was decided to raise the compression of the Ruston engine to firing temperature, this was effected by simply removing the outer chamber, the uncooled bulb, the spray valve then being fitted directly in its place. (Fig. 7.)

At that time a nozzle with a single fine slot cut across the end was used to conform to the flat chamber between the valves.

The consumption of the Ruston higher-compression

engine was reduced by this means to 0.4 lb. per b.hp.—to fall still further in later years. After the war it became their standard horizontal engine.

The next step in power and speed was taken when in 1919 the author designed a larger engine of the Vee type for submarine use. This engine had cylinders of 17 in. diameter by 20 in. stroke, with revolution speeds up to 550 per minute. The combustion chamber was of the two-cell type with turbulent neck, and two horizontal valves were employed. The injection valves were automatic, with directly connected pumps. The fuel pump was of a special quick-action design, to be developed later into the now well-known flash type. Supercharging was obtained by using the enclosed crankcase as a pump, the two downcoming pistons serving to discharge air through a rotating ring valve and ports alternately to each cylinder at the end of the outward stroke of the piston.

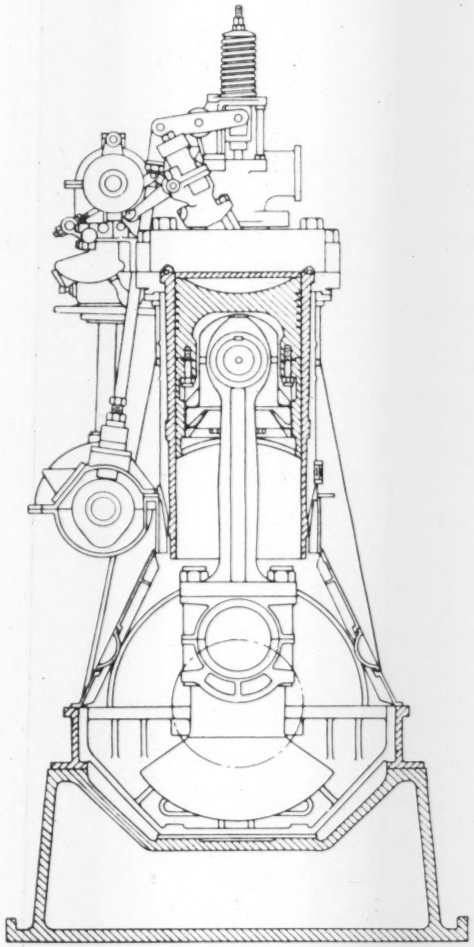

FIG. 4 SUBMARINE ENGINE DESIGNED BY AUTHOR IN 1915

The engine was constructed by Messrs. Beardmore of Glasgow. It is to be regretted now that no description was published of it or its tests at the time, for its operation was so satisfactory.

The next move forward in increasing speed was when the Air Ministry decided to investigate the possibilities of the oil engine for aircraft purposes, on preliminary proposals submitted by the author.

At that time, the chances of success were not considered at all rosy. It was thought that combustion would not be rapid enough. This was due probably to the rather set ideas of the Diesel-engine school, working at constant pressure. Viewed from the English solid-injection practice with more or less constant-volume addition of heat, the situation was much more promising, for it resembled gas-engine practice at very high compression ratios.

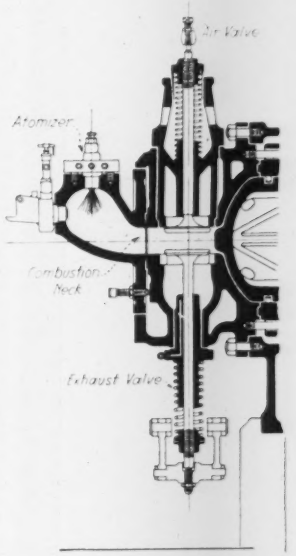

FIG. 5 TWO-CELL TURBULENT COMBUSTION CHAMBER

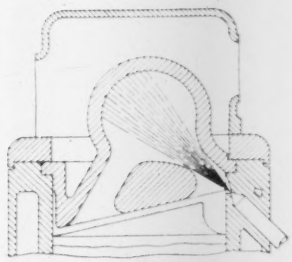

FIG. 6 TURBULENT AKROYD STUART CYLINDER HEAD

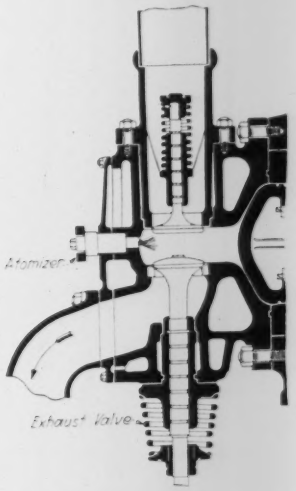

FIG. 7 OUTER CHAMBER OF FIG. 5 REPLACED BY SPRAY VALVE

The problem of increased speed was attacked by a careful consideration of the matter from all angles and available experience.

Combustion. There was a general tendency at this time to keep to the constant-pressure cycle; all concerned seemed to fear high maximum pressures. Later it became clear that for high speeds to be achieved this inhibition would be a serious handicap, materially affecting fuel consumption, mean pressures, color of exhaust, etc.

After a good deal of experimental work, high maximum pressures were finally faced squarely in the design and the constant-volume cycle accepted. In practice, however, this cycle is modified, i.e., some part of the heat being added at constant pressure.

The important factor of turbulence was then considered and a long time taken before coming to a decision. Finally, however, while it was realized that a turbulent two-cell type might give higher rates of combustion—at any rate, when the atomization was not too perfect—it was thought it could not attain as

high a mean cylinder pressure as the one-cell would do.

The guiding principle of oil-engine design, if high mean pressures are to be attained, was then as now to get at or search out all the air possible with the oil spray, and the single cell seemed to offer better prospects in this respect.

To adopt a less turbulent device, the author felt, would call for a much improved and more accurate pump action and injection of the fuel than was then available.

Injection. Though the most widely known engine using heavy oil fuel efficiently was the Diesel, this could not be said to be the case in parts of England.

It was realized, however, that though air injection as invariably employed had certain advantages, the added complication and weight of the air compressor with the lower mechanical efficiency ruled it out for air work.

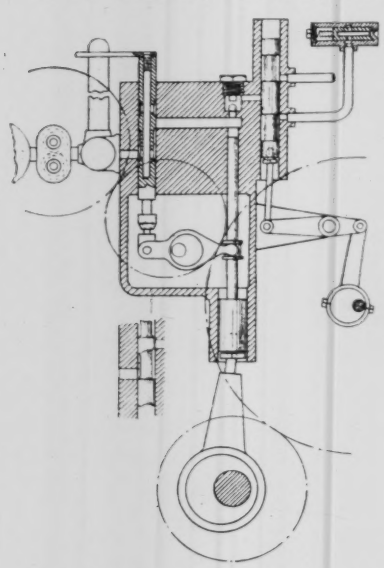

FIG. 8 INJECTION PUMP AS FINALLY DESIGNED

In view of the progress in higher speeds that had been made with direct airless injection on the previous engines, and the special knowledge possessed by those concerned with this type, it was decided to continue with it; also, because of the higher speeds arrived at, automatic spray valves seemed to promise better.

How to get sufficient oil in a fine enough spray into the combustion chamber in the shorter time was a problem that led to nozzles with up to 30 holes being at first designed. The Brons cup was also considered—the one in which the fuel is dropped in on the suction stroke, and also the developed form, where it is injected on the compression stroke.

Work finally commenced with automatic spray valves, and they were used throughout. They were tried centrally with a single valve, and circumferentially with four.

Injection Pumps. The fuel pump used with an automatic spray valve is the arbiter of successful action—rapidity, with no after effects like dribbling. This was well known from the experience with the Lincolnshire type, though of course in that case the engine ran at much lower speeds.

The pump as finally designed is shown in Fig. 8, and the design remained practically unaltered throughout, though it was steadily improved in accuracy and fine fitting.

Spray Valves. As stated above, the mechanically operated valve was discarded because of the high speed called for and the difficulties encountered in the earlier engine. The pepper-pot type of nozzle was finally selected, though the annular and other types were tried but did not give good results, due perhaps to their accuracy not being high enough.

The investigation of all the cylinder processes necessarily involved in successfully producing an injection oil engine with relatively small cylinders as compared with those in use, and to run at a much higher speed, called for a physical examination of the injection problem much more thorough than had been usual.

It was determined to attack the matter by working on a single-cylinder engine and to accumulate through various and extended tests the necessary data called for by the problem of producing a high-speed, lightweight oil engine.

This unit, which began work in 1923, had a cylinder 8 in. in diameter × 12 in. stroke, an aluminum-alloy crankcase, and the new flash-valve fuel pump running at engine speed, one plunger supplying two cylinders alternately, controlled by a switch valve as shown in Fig. 8.

At first, with the important parts not tight, etc., the results obtained were poor, but with improvements gradually taking place it became necessary to use some additional measuring apparatus, optical and volumetric, to further carry on the research.

The oscilloscope was employed, and by fitting it to a nozzle (spray valve) coupled to the second discharge of the pump (one plunger fed two cylinders as it ran at crankshaft speed), the action of the jet could be very carefully examined and the discharge weighed.

Experimenting steadily went on, the period of dribble falling from as much as 20–30 deg. to 3–5 deg., with improvement in economy and color of exhaust.

Many arrangements in size and number of holes in the spray nozzles were tried, and the piston top modified from a high center (like that Hesselman used) to a cup type; eventually a flat top, a good workshop design, was adopted and stuck to, speeds varied up to 1300 r.p.m., and powers up to 120 b.hp.

The turbulence set up by the inlet valve was used in general and found adequate, but some tests were carried through with the guided or rotational type with so little, if any, benefit that they were dropped and the valve turbulence returned to.

As the bulk of the air was at the outside of the combustion chamber, it seemed that in small cylinders, side jets would be the ultimate solution. Four atomizers were therefore tried, and then two tangential ones, the results being similar to those obtained with the center spray but not (as then tried) such as to justify doing away with the relatively simpler center jet.

While the author was an advocate of the high compression ratio, the authorities were not, so the final compression pressure was 420 lb. and the rating 102 lb. b.m.e.p. at 800 lb. maximum pressure.

though it was demonstrated that improved fuel economy resulted from the higher compression ratios.

Variable valve timing was next tried and some improvements made over gasoline-engine practice, such as closing the inlet valve earlier—with improvement in compression.

Varying the length of induction pipes was also tried, but though an increase in power resulted with a 5-ft. 6-in. pipe, its use was not continued. The pump was then made to deliver before the center of travel and not at it, and after further experiments the chief research tester, Mr. E. T. Vincent, obtained results, checked by Prof. A. L. Mellanby, of the Royal Technical College, Glasgow, as follows:.

Test No.	1	2	3	4
Duration	1 hour	1 hour	1 hour	10 min.
R.p.m.	1008.7	1120	803.5	1008
Brake load, lb.	198	145	128	227.7
Brake horsepower	83.2	67.7	42.5	95.6
B.m.e.p., lb. per sq. in.	103	74.6	65.4	117
Fuel: net lb. per hr.	29.45	21.08	13.65	...
Fuel: lb. per b.hp-hr.	0.354	0.311	0.319	...
Lubricating oil, lb. per b.hp-hr.	0.040	0.123	0.029	...
Maximum pressure	800 lb. per sq. in. in all cases			

After sufficient progress had been made with the earlier tests of the unit cylinder, the six-cylinder engine was then completed and tested. The average results of a 3-hour shop test made under Air Ministry officials are as follows:

Revolutions per minute	1007
Brake load, lb.	506
Brake horsepower	424
Brake m.e.p., lb. per sq. in.	92.5
Fuel oil: lb. per hour	154.7
Fuel oil: lb. per b.hp-hr.	0.365
Lubricating-oil inlet and outlet temperatures, deg. fahr.	121–133
Lubricating-oil pressure, lb. per sq. in.	47
Water to engine, inlet and outlet temperatures, deg. fahr.	140–150
Fuel control	22.5 deg.
Timing	0.5 deg. advance
Mean efficiency	86 per cent
Indicated horsepower	493
Fuel: Shell Mexican Diesel oil [sp. g. = 0.885 at 15 deg. cent.; flash point = 89 deg. cent. (close); calorific value = 17,550 B.t.u.]	
Lubricating oil: "Sternol" Aero Oil No. 1 (sp. g. = 0.93 at 60 deg. fahr.)	

These results it will be agreed were very good for the time (1924), and sent quite an optimistic thrill through all concerned.

The successful tests of this experimental 6-cylinder engine decided the Ministry authorities to proceed with engines for practical air service. The extraordinary high economy and the use of a safe fuel (a flash point of over 200 deg. fahr.) were features of great value for certain kinds of aircraft, particularly airships and long-distance planes, where the ratio of weight to horsepower is not so fundamentally important.

We may now therefore proceed to a description of these engines and those as actually built for the airship *R-101*.

All sizes were of the straight-line type, the 6-cylinder for airplane service, and the 8-cylinder for airship. An interesting example of the former, of the inverted type, the cylinders hanging below the crankshaft, was built and tested. All these engines had cylinders with a diameter of $8^1/_4$ in. × 13 in. stroke.

For the airplane-service engine a speed of 1400 r.p.m. gave on test up to 700 b.hp. with a weight of under 4 lb. per b.hp.

For the airship engine the speed was not to exceed 1000 r.p.m., with a power of 650 b.hp. maximum. The rotational speed was fixed at this figure because it was desired to direct-couple the engines to the propellers and yet retain a fairly high degree of efficiency, a compromise of doubtful value.

The engines were not made reversing, this being taken care of by using propellers having movable blades. These propellers were 18 ft. in diameter.

The engines were put in construction, but workshop difficulties arose and continued for a long time. The most outstanding ones were those encountered in the aluminum-alloy crankcase and the crankshaft. The crankcase failed from the large centrifugal forces set up by the two unbalanced (in that plane) center cranks and connecting rods. This resulted in the rupture of the case at the center bearing. Many cases were made and further strengthened step by step, with resultant extra weight. The trouble was finally cured by fitting through steel bolts at each journal bearing from side to side of the crankcase, and making the outside of the case fish-bellied and U-shaped in section. This succeeded, but afterward foundry cracks again held matters up.

These cracks, though small, were so persistent that, as the time for delivery became short and it was not felt proper to risk such cases in flight, steel cases were considered. A trial casting of a complete case 0.3 in. thick having proved successful, it was eventually decided to fit all engines for the airship *R-101* with such steel cases, although the weight went up 1000 lb. per engine.

It was intended in the meantime to perfect the aluminum cases, and then refit them to the engines later. The new case was ready about the time the ship started on her last flight.

The other great delay in arriving at the final engine was due to torsional crankshaft vibration, to meet which the crankshaft was increased in diameter—to push the major critical outside the running range—and as drop-stamped forgings were insisted upon for strength and safety reasons, the change meant new dies. The size of the hammer required, viz., 5 tons, was another limitation. This difficulty, together with the high torque variation, resulted in wooden propellers being fitted and used on all airship flights.

A view of the engine given at the beginning of the paper clearly shows its rugged construction, which in most respects is more like that of engines employed for land duties; in fact, similar engines were supplied to the Canadian National Railways for rail-car service.

The fuel pumps had four plungers working in a block of duralumin and running at engine speed—one

plunger for two cylinders, with a switch valve to select the right one. The flash valves were operated by rocking levers from the plunger drive, and had helical cut-off edges; rotating these by a rack and pinion controlled the cut-off, and thus the right amount of fuel required for each speed and power. Governors were not fitted as in the rail-car engines.

Spray valves of the central automatic type were fitted and pepper-box nozzles used having 8 holes of 0.015 in. diameter.

The pistons were of forged Y metal cut from the solid. The cylinder liners were of hard steel, fitted into the one-piece cast-steel case. The rest of the engine was of normal automobile-like construction.

The engines were started up by a small auxiliary engine and a Bendix-type gear; the engine, however, was to be replaced later by an electric motor.

The 6-cylinder engines for planes, running at a higher speed, had geared-down propellers. They were to be tried on the airships as an alternative.

The fuel used had the high flash point of 212 deg. fahr., though any well-known Diesel-type fuel was suitable, and many such were tried.

The "steam" type of cooling was used and the circulation was effected by thermo, a system that worked admirably in service. The radiators were slung under the main ship itself, and could be drawn within when required for cabin or other heating.

In all the flights wooden propellers were used, and at a later date two of the engines were made reversing.

Engines of this type were built for rail-car use and can be seen in operation in Canada, while the Westinghouse Company, the owners of the American rights, have examples running in the States.

Of the tests made on these engines, the following, conducted by Professor Mellanby, are of interest.

Test series	Duration of test, hours	Speeds, r.p.m.	B.hp.	Fuel, lb. per b.hp-hr.	Cooling-water temperatures Inlet, deg. fahr.	Outlet, deg. fahr.	Fuel
A	4¼	689.3	160.26	0.418	121.5	127.4	Shell-Mex. Diesel
B	3	700.0	172.0	0.385	120.0	128.0	Do.
C	3	1007.0	424.0	0.365	140.0	150.0	Do.
D	1	1023.0	263.0	0.355	181.0	185.5	Anglo-Persian

It is not the purpose of these notes to go further into details, as what has been given indicates sufficiently the development of the high-speed oil engine in its earlier years in England.

Generally, the combustion and injection were based in one way or another on the experience obtained during the development of the Lincolnshire oil engine, while the engine was relatively standard in design, with no special devices except the pump to secure the results obtained.

In the very wide-reaching research work on high-speed oil engines that has been carried on, notably in the United States, and particularly that on the oil jets themselves, one often feels that a more direct connection should be established with actual practice. Even yet it is often necessary to make special experiments with a new design, particularly as regards the combustion chamber and the oil jets.

The question of turbulence is hardly yet properly classified in its various forms and degrees, and in relation to the jets.

The old high speeds used in Lincolnshire practice through the neck of the bulb for rapid combustion are now the object of research by some. This neck was the key to the success of the earlier oil engines, and its details were always kept secret by the chief designer or experimenter. Just how it acts on the jets would constitute a fruitful line of investigation for research workers.

One factor—and an outstanding one—in the system of mechanical (airless) injection is the very high degree of accuracy of finish necessary in all the apparatus used, and the due relation between each part—pump, conduit, and nozzle. Today, however, mechanical injection is more limited in its range than is air injection.

The next step will be to extend the flexibility of this motor to allow a wider speed range so that it may run at much higher speeds in which the forced turbulence of the Akroyd Stuart neck will play its part, and at low ones, where by a controlled change it may do the same.

The Hot Forging of Brass

IT IS WELL KNOWN that copper-zinc alloys containing about 60 per cent of copper possess good hot-working properties and can be rolled or forged with comparative ease at high temperatures and, in fact, alloys of this type constitute the basis material of many of the hot-workable copper-rich alloys. Alloys of this kind are produced in strip and sheet form by hot rolling and also in the form of rod and section by hot-rolling and extrusion processes. Such rod constitutes raw material for such processes as hot stamping or hot forging.

For making small parts the drop press is preferred because of the speed at which it can be operated, and the chief limitation of its use is in the capacity of the hammer. For making larger parts air-controlled screw presses are used, and for some alloys and special shapes the slower flow of metal in the die is an advantage. Presses having a capacity up to about 800 tons are now used.

Several types of dies are used for hot pressing, and die design is based chiefly on experience. The amount of draft varies from 1 deg. to 5 deg., and, in addition, a flash clearance of 0.023 in. to 0.080 in. must be allowed and also an allowance of about 0.012 in. provided for thermal shrinkage of the metal. Tolerances of about plus or minus 0.005 in. can be readily maintained, and generally an average of about 30,000 pieces can be expected from one die.—*The Metallurgist* (Supplement to *The Engineer*), March 27, 1931, p. 48.

FIG. 1 BATTERY OF 105-MM. FIXED-MOUNT ANTI-AIRCRAFT GUNS IN ACTION

Development of Anti-Aircraft Matériel

New Types of Anti-Aircraft Guns—Improved Methods for Directing Fire of Guns and for Locating and Illuminating Hostile Aircraft

BY G. M. WELLS,[1] WASHINGTON, D. C.

ONE of the most important military developments which has been carried on by the War Department as a result of World-War experience has been the production of new types of anti-aircraft guns, and improved methods for directing their fire and locating and illuminating their target.

The engineering fraternity has had a number of reports in past issues of MECHANICAL ENGINEERING presenting recent progress in the evolution of new and improved types of military aircraft; the progress of the motor transport and tank "mechanization" programs; and other developments of similar type, many of which have received wide public notice.

It is interesting to note, however, that the development of defenses against air raids, which in case of a military emergency would be of real and immediate concern to engineers, industrialists, and civilians far removed from the "front," has not yet received that degree of general attention and understanding which it deserves and will eventually receive.

As will be shown later, this condition has not been due to any lack of progress in anti-aircraft development. In fact it may be said that the evolution of a new understanding of anti-aircraft strategy and its relation to the other combat arms of the service—together with a refinement of the matériel to be employed in combating air raids—has been one of the most thoroughly studied problems in the War Department's post-war experience.

From the strategic standpoint, the outstanding contribution has been a better conception of cooperation and identity of missions between the anti-aircraft forces and the air corps. This plan of cooperation has in turn been based largely on the remarkable improvements in anti-aircraft fire which have been achieved in recent years.

The mission of the air corps is essentially offensive. The primary object of the development of greatly improved types of combat planes, attack planes, and bombing planes is offensive operations against enemy aircraft, enemy ground troops, and enemy supply and administrative centers. In addition to providing air forces for attack on a wide variety of objectives, means must be provided to protect our own army areas, supply bases, and non-combatant areas against air bombardment.

The offensive carried out by the air force is one method of curtailing enemy bombing activity. But defense forces must also be stationed at vulnerable points in army and interior areas to defend against air raids. If this defense is entrusted solely to the air force, particularly in a country as large as the United

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States, it will mean the diversion of large numbers of fighting aircraft from an offensive rôle to a defensive one.

For this reason, the anti-aircraft forces have been recognized as a powerful ally of the air corps. In army areas adjacent to the "front" they supplement the air forces in protecting supply dumps, headquarters, rail heads, and other vulnerable centers. In the interior areas, sometimes thousands of miles from the theater of operations, the anti-aircraft forces may take over

Fig. 2 Battery of 3-In. Mobile Anti-Aircraft Guns in Action

Fig. 3 3-In. Mobile Anti-Aircraft Gun in Traveling Position

the entire responsibility for protection against air raids.

It is obvious that the success of such a program is largely dependent on the production of anti-aircraft equipment which will be able to effectively destroy hostile bombardment aircraft. As a guide to the powers of anti-aircraft artillery it is of interest to study the records which were achieved by anti-aircraft units, using hastily devised equipment, during the closing months of the World War.

"Archie," as the anti-aircraft gun was nicknamed, came in for a good deal of skeptical criticism in World-War days. However, it is not generally known that, particularly in the defense of Paris, anti-aircraft guns played the major rôle with conspicuous success. Most of the raids on Paris occurred at night, when the defense was entrusted largely to the guns. Of the estimated total of 500 German bombing airplanes directed toward Paris, only 50 of them passed the anti-aircraft defenses of the city. Fifteen enemy bombers were shot down, and German reports indicate that a large number of others were turned back because of damage which impaired their ability to continue on their mission, but which did not cause them to crash. At one time 22,000 kg. of bombs were sent over to be dropped on Paris. Only 1060 kg. were actually dropped. The rest were turned back and wasted, as the German bombers could not land with a load of bombs.

The German anti-aircraft batteries were also remarkably efficient in defending against allied air raids. The operations of the British Independent Air Force against the munitions plants in the Cologne area were greatly handicapped by the very highly organized defenses grouped at these points. At the front the German "Archies" were highly respected by the allied fliers. A German report states that in one day seventeen allied airplanes were shot down along the Somme and the Arve.

If records such as this could be achieved by the improvised equipment of the World-War period, it is not surprising that the progress of the last few years has made it possible for the anti-aircraft gun to be established as a very important element in the protection of vulnerable areas against raiding aircraft.

Requirements for Anti-Aircraft Equipment

In defining the requirements for anti-aircraft equipment for the American Army, probably the most outstanding necessity is mobility. Anti-aircraft guns must not only be able to accompany troops on the march, but they must also be moved at high speed from place to place to meet threatened air attacks. Fixed anti-aircraft defenses are also used to defend important areas such as the Panama Canal and various Coast Defense fortifications, but the greater requirement for general defense duty is the highly mobile type of gun.

In view of the fact that the manufacture of American military equipment is based on an industrial-mobilization plan which visualizes a large expansion of manufacturing facilities in case of emergency, new equipment must be designed with this type of production in mind. The designs have been carried out with a view to utilizing the latest production methods which have been developed by peace-time industries, and in some cases the Government study of these methods has contributed to the refinement of industrial methods.

For example, welded structures now largely replace castings, and an impressive program of research in welding has been carried out at Watertown Arsenal. Guns are now made by centrifugal casting and cold-working processes, and metallurgical progress in industry has been assisted and supplemented by the work of the metallurgical laboratory at Watertown Arsenal. As a result the new guns, carriages, and fire-control equipment are built in accordance with the highest industrial standards; all units are designed with a large war-time production in mind; and the Ordnance Department maintains close touch with industry through the district ordnance offices which are maintained in various parts of the country.

The foregoing discussion not only illustrates the great importance of the military mission which is assigned to the anti-aircraft units, but also shows how this military value has been largely predicated on the remarkable improvements which have been made in anti-aircraft equipment. The present high degree of development of the equipment will be apparent as we proceed to summarize the most important development work which has been carried out.

105-MM. FIXED MOUNT

The most powerful anti-aircraft weapon yet tested by the Ordnance Department is the 105-mm. fixed weapon which is intended for permanent emplacement in important seacoast or industrial areas (Fig. 1). It will not replace the standard type of 3-in. gun, but will act as a powerful auxiliary where an increase in the zone of effective anti-aircraft defense is needed.

The gun is 60 calibers in length (i.e., the length is 60 times the diameter of the bore), which gives it the distinction of being the longest gun in calibers ever built in this country. However, the most unusual feature of this gun and the new 3-in. gun, which will be described, is its use of a removable liner, which permits the inner member of the gun to be replaced in the field when it becomes eroded after a large number of rounds have been fired. The cost of a replacement liner is less than the cost of retubing in an arsenal, and the entire operation can be performed in a few minutes by the gun crew, using simple hand tools. Both the gun and the liner are made by the cold-work, or auto-frettage, process. A continuous fuse setter has been provided for this mount which insures that the fuse setting will be progressively changed, in accordance with the changing data transmitted from the gun-control unit, until the instant when the shell is removed from the fuse setter and placed in the loading tray of the gun. The gun is laid on the target by an indirect system of gun control which will be described in detail later.

3-IN. MOBILE MOUNT

The latest mobile mount developed by the Ordnance Department for anti-aircraft use has many unusual features, probably the most conspicuous of which are the long outriggers which are extended to provide a firm footing for the gun when it is firing (Fig. 2). When on the march, the carriage is carried on balloon-tired bogies (Fig. 3) which are removed from either end of the carriage when it is placed in position. Two hoisting screws are provided below the center of the carriage to raise and lower it when the wheels are removed or replaced. In traveling position the outriggers are folded back on the center unit of the carriage and the gunners' platforms are folded up on either side of the gun. The gun can be emplaced in about fifteen minutes; it is stable under all conditions of firing, and it is highly mobile. Ordinarily it is towed by a six-wheel truck, but under very difficult cross-country conditions it may be necessary to use a small tractor. A road speed of 40 miles an hour can be maintained, and in the words of the soldier who rides the gun as brakeman, "It rides like a baby carriage!" This gun is also controlled by an indirect gun-control system, is fitted with a continuous fuse setter, and has a semi-automatic breech action in which the recoil of the gun opens the breech and ejects the spent shell case, the breech block closing automatically when the new shell is pressed home. The normal rate of fire is about 25 shots per minute.

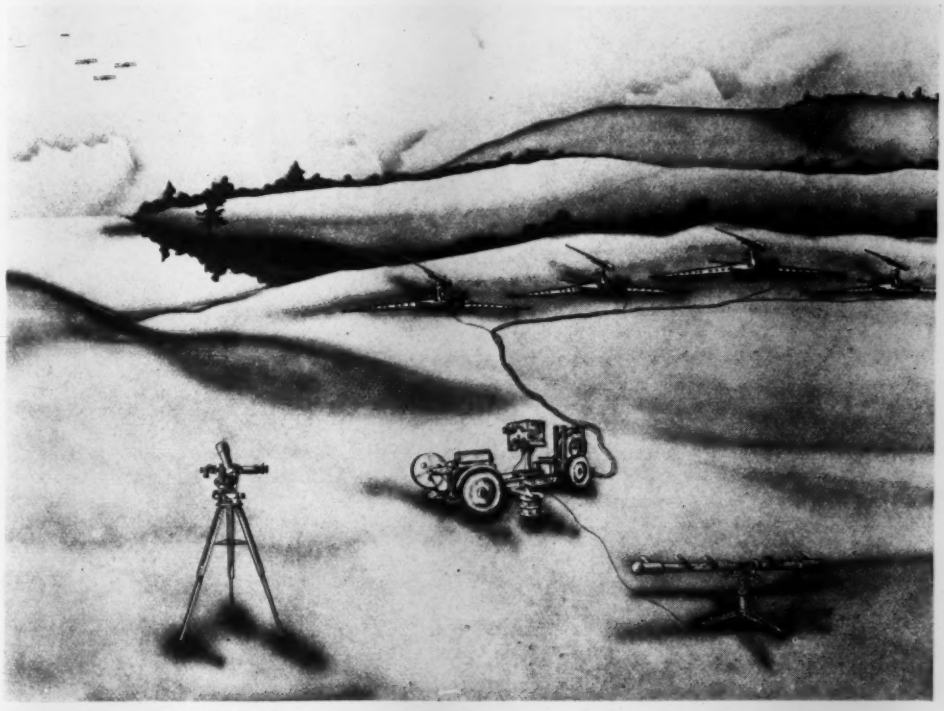

FIG. 4 SKETCH SHOWING FIRE-CONTROL SYSTEM FOR 3-IN. MOBILE ANTI-AIRCRAFT BATTERY

37-MM. AUTOMATIC CANNON

Experiments have shown that the 37-mm. high-explosive projectile with a supersensitive fuse is very destructive, a single hit being ordinarily sufficient to disable an airplane. This has led to the development of a fully automatic 37-mm. gun. The general details of the mount are somewhat similar to those of the 3-in. mobile mount except that the wheels are not removed

when the gun is in action. The ammunition is made up in clips of five, in a manner similar to the familiar caliber .30 service-rifle clips on a much larger scale. These clips are successively inserted in the breech mechanism, and a rate of fire of approximately ninety shots per minute can be attained with a projectile weighing $1^1/_4$ lb.

MOBILE MULTIPLE-MACHINE-GUN MOUNTS

Troops on the march, motor convoys, etc., furnish a particularly vulnerable target for high-speed, low-flying attack planes armed with machine guns and small bombs. A proper ground defense against such an attack requires special equipment and presents many perplexing problems. Surprise is certain to be an important element in the attack, and the defensive equipment must be capable of going into action almost instantly. A heavy volume of fire is necessary in order to disable the attacking plane in the very short time available. The choice of defensive weapons is quite evidently restricted to the caliber .50 machine gun, or rather several such guns mounted and fired in multiple on a single carriage. This development problem has received particular attention, and two different types of mounts fulfilling the general requirements have been built.

FIG. 5 NEW STANDARD INSTRUMENT TRAILER AND ANTI-AIRCRAFT DIRECTOR—MANNED

FIG. 6 SOUND LOCATOR READY FOR ACTION

FIG. 7 ANTI-AIRCRAFT SEARCHLIGHT AND SOUND LOCATOR IN TRAVELING POSITION

AUTOMATIC GUN CONTROL

As mentioned above, the 105-mm. and 3-in. guns are controlled by the indirect method illustrated diagrammatically in Fig. 4. Here we have a battery of four guns, electrically connected to a gun-control computer, generally called an "anti-aircraft director," and a height finder, which in conjunction automatically predict the future position of the airplane target and apply all ballistic corrections for wind and drift, influence of air density, changes in muzzle velocity, etc.

The predicted and corrected gun azimuth, elevation, and fuse setting are transmitted to each of the four guns by an alternating-current, self-synchronous, data-transmission system which positions "match the pointer" dials on each gun. These dials have two concentric pointers, one operated electrically by the data-transmission system and the other connected to the gun or fuse setter mechanically. The gun pointer, or fuse-setter operator, has only to manipulate his handwheel so that the pointers on the dial are "matched" in order

to position the gun or set the fuse in accordance with the data received from the computer.

The automatic anti-aircraft data computer developed by the War Department in collaboration with the Sperry Gyroscope Company utilizes a principle which is theoretically exact in its solution of the problem rather than admitting the compromises which have been allowed in previous types of gun-control computers. It must be admitted, however, that the solution, though theoretically exact, does not result in perfect accuracy of fire. The projectiles, passing through several atmospheric strata, are acted upon by variable conditions of wind and air density which are very difficult to determine in advance from the ground. The maneuverability of the modern airplane makes it difficult to predict where it will travel during the time of flight of the projectile. In spite of these very real difficulties, satisfactory percentages of hits are expected and actually obtained in tests approximating service conditions.

The gun-control computer is mounted on an instrument trailer (Fig. 5) which accompanies the battery on the march and carries, in addition to the computer, the cables which connect it to the guns, a gasoline-driven generator and storage-battery-driven motor-generator for supplying electric current for the transmission system, and the stereoscopic height finder used in connection with the data computer.

Height Finders

In accomplishing the prediction and computation of the data needed to train the battery of guns, it is necessary to obtain the height of the target. This is done by using a range finder which measures the "slant range" to the target, and then by optical or mechanical methods converts this to altitude.

Two types of range finders are available for this purpose. One of them is the familiar coincidence type, in which the field is divided into two halves and the instrument adjusted by moving the two halves of the image until they coincide. This instrument is comparatively easy for the average man to operate, and is accurate, but because the field is "flat" it does not permit the operator to judge whether the bursts which he observes adjacent to the target are "over" or "short."

Consequently, we prefer range finders using the stereoscopic principle, which permit the operator to exercise his "depth perception" and which are dependent on his ability to focus the image of the target so that it coincides, in its apparent distance from his eye, with the distance of reference points in the field of vision. The only serious objection to this height finder is the difficulty in selecting and training operators who have the necessary stereoscopic sense.

Sound Locators

The guns and gun-control equipment described above would be ineffective if it were not possible to locate the airplane target. In the daytime an airplane flying at high altitude is at best an elusive object for direct visual observation, and at night, when most bombing operations take place, some method of supplementing or replacing visual observation is essential.

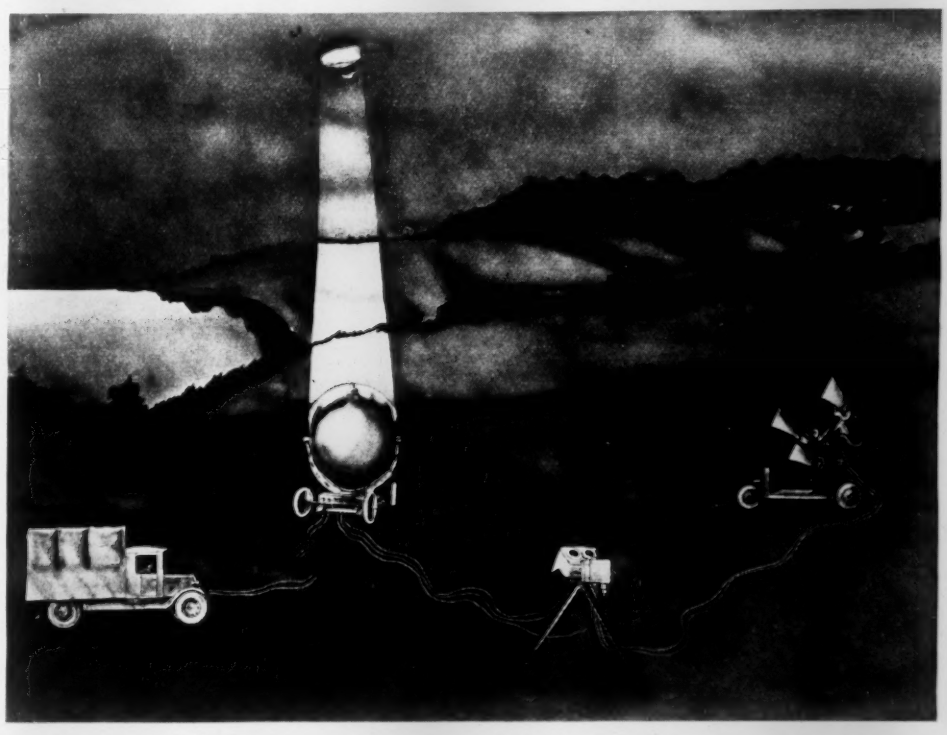

FIG. 8 SKETCH SHOWING SEARCHLIGHT-SOUND-LOCATOR INSTALLATION

The latest type of sound locator is shown in Figs. 6 and 7. There are two tracking operators, one who trains the sound locator in azimuth and the other training it in elevation. These operators must depend on their binaural sense and move the sound locator so that the volume of the sound heard by each ear is equal, in which case the sound locator is "on" the target.

Fig. 8 illustrates the interconnection of sound locator and searchlight. The azimuth and elevation of the sound locator, corrected for the time lag due to the time required for the sound to travel from the airplane to the ears of the listeners, are transmitted electrically and displayed by pointers on the dials of a comparator unit which is set up at a convenient position in the field.

By matching these pointers with the pointers of a distant electrical control gear connected to one of the searchlights, this light is trained in accordance with the sound locator. The range at which the sound locator can "pick up" an airplane exceeds, under favorable conditions, the range at which it can be observed by the naked eye, and it can accurately locate an airplane target at ranges considerably in excess of the maximum searchlight range, or about seven miles.

SEARCHLIGHTS

The development work in high-intensity-searchlight design carried on for several years by the War Department and the Sperry Gyroscope Company has resulted in a searchlight for anti-aircraft use which, as determined by careful investigation, gives the maximum range and illumination which can be practically utilized in military service. This has been achieved by using a high-intensity arc in combination with a searchlight reflector 60 in. in diameter. One of the unique developments which has made it practical to use a searchlight of this size for field service has been the use of aluminum castings for the searchlight drum. This method of construction gives great strength and rigidity with minimum weight. The complete searchlight unit is mounted on a mobile base, together with motors for moving it in azimuth and elevation, with a ventilating system for preventing light-absorbing deposits on the mirror and for keeping it cool, and with all the electrical controls for handling the arc. The mobile unit is entirely self-contained, can be easily handled, and can be transported on a motor truck especially equipped for this purpose. Power for the searchlight is supplied by a generator driven by the truck motor.

The War Department development of anti-aircraft equipment, of which the foregoing is but a brief outline, has achieved several important results. It has brought about the evolution of equipment which is believed to be at least the equal of that used by any foreign power. It gives assurance that in case of a military emergency the War Department will be able to immediately put into production modern anti-aircraft equipment designed to take advantage of the most progressive industrial methods. But by far the most important result has been the development of equipment of sufficient fire power, accuracy, and mobility to insure that the artillery regiments, which are charged with the conduct of our anti-aircraft defenses, can effectively assume the proper share of responsibility for protecting the vulnerable areas of the country against hostile bombing raids.

International Terminology of Liquid Fuels

THE author calls attention to the confusion of terms in this field. The substance known in Great Britain as "petrol," he says, is a case in point. This is a product of the distillation of petroleum; its specific gravity ranges from 0.70 to 0.78, and it is used chiefly as a fuel for internal-combustion engines. In Germany the term "petrol" is unknown; there we have to ask for "Benzin." The German, then, who comes to England and asks for "benzene" will be sadly disappointed; he will probably be given what, in his own language, is "Benzol," the chemical formula of which is C_6H_6. The expression "benzene" (spelled also "benzine"), however, is also used in Great Britain to designate the liquid used in the household for cleaning purposes. The German aforementioned should ask for "petrol" or "motor spirit." These expressions, however, have nothing to do with the German "Spiritus" and "Petroleum." "Spiritus" is in English "methylated spirit," or simply "alcohol," and "Petroleum" is "paraffin oil."

The foreigner might now suppose that the terms "petrol" and "motor spirit" are in universal use in all English-speaking countries to designate the same liquid. This assumption would be very wide of the mark. In America automobiles are run on "gasoline."

In France, too, one experiences difficulties if one asks for petrol. The expression that is current there is "essence." In the other European countries the term "benzin," or derivatives of it, is in general use. In Latin America the expressions "gasolina," "esencia," and "bencina" are found.

A similar confusion prevails with regard to the expression "petroleum." In Great Britain this term is applied to a heavy, dark, tarry, mineral oil found in nature, from which petrol and other substances are obtained by distillation. When the German speaks of "Petroleum," he means the oil generally called in England "paraffin oil." In the United States of America, however, the official term for the English "petroleum"—once more according to the definition put forward by the American Society for Testing Materials—is "crude petroleum." At the same time, both England and America use the expression "crude oil," too. The expressions current in Germany are "Erdöl" and "Rohöl." The corresponding term in France is "petrole brut" or "huile brute," in Italy "petrolio" or "olio greggio," and in Russia "neft."

The illuminating and gas oils used in internal-combustion engines, especially of the Diesel type, are comprised in Germany under the name of "Treiböle" (motor oils). In international commerce they are generally called "gas oils," while the oils commonly used for firing furnaces are called "fuel oils" (in German "Heizöle"). In Great Britain, on the other hand, both "Treiböle" and "Heizöle" are often included under the common name of "fuel oils." The expression "Diesel oil," adopted from the German, would appear to have become familiar in England. The limits of its application are not clearly defined, however, since the specific gravities of some of the heavier Diesel oils are within the range of the fuel oils. The only possible way of establishing a clear distinction would be to differentiate between distillates and residues. The latter would be the fuel oils, which, of course, may be mixed with distillates of high boiling point.—Dr. O. Zaepke, Berlin, in *Engineering Progress*, vol. 12, no. 1, Jan., 1931, pp. 9–10.

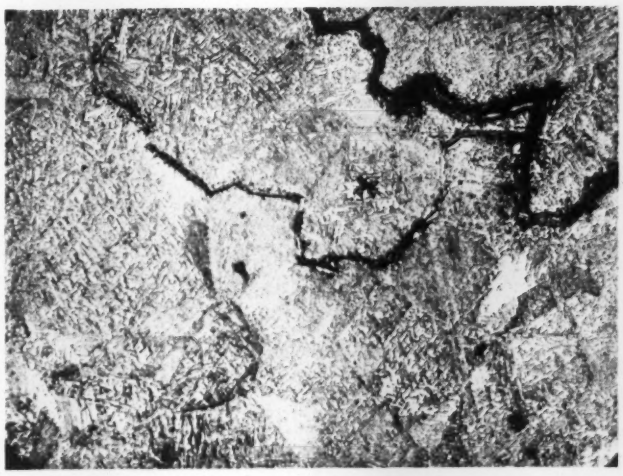

FIG. 1 INTERGRANULAR FRACTURE IN CR-MO STEEL, PRODUCED BY A SLIGHT STRESS AT A WHITE HEAT AFTER FUSING. × 70
(The cracks follow the grain boundaries and are filled with crystalline oxide formed by the oxygen which entered after the crack had opened up.)

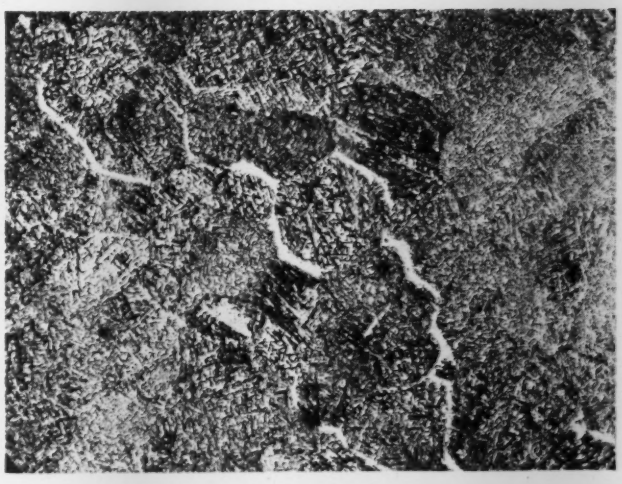

FIG. 2 HEALED FRACTURE NEAR THAT IN FIG. 1. × 70
(This illustrates clearly how the fracture follows the grain boundaries. The white boundary lines are composed of ferrite formed by the reduction of the iron oxide by carbon in the steel.)

The Cause and Prevention of Heat Cracks in Aircraft Welding

A Study of Localized Stresses

By H. S. GEORGE,[1] LONG ISLAND CITY, N. Y.

HEAT cracks that occur during the welding of steel tubing and sheet are identical in nature with heat cracks that sometimes occur in steel ingots or castings. Foundrymen have evolved expedients which help to prevent heat cracks. Usually the cooperation of the designer and the steel melter is required. It is customary in steel founding to put some thought on the matter of the design of the casting and on the design of the mold and its parts, with the idea of preventing heat cracks and avoiding the necessity of scrapping the casting. But steel founding is a very old practice, and welding, particularly aircraft welding, is young. The accumulated metallurgical knowledge of the steel founder is not as a rule available to the designer of welded structures or to the welder. Many welders know how to safeguard against cracks, but they sometimes come across a mysterious case with which they can do nothing, and often they blame the trouble on the composition of the base metal or the rod. Designers are in the habit of avoiding certain arrangements, knowing through their experience that cracks sometimes occur with certain placements of welds.

A number of practical "don't's for welders" have been formulated and found very useful. But some of them are needlessly restrictive and do not impart the security that comes from an understanding of the principles involved.

Steel that has been fused or heated almost to fusion, unless it is subsequently hot worked, is devoid of ductility at a white heat. The temperature range, where ductility is absent, varies with different steels. The individual grains are plastic, but they do not cohere to each other. If contraction or some such local stress is present the grains are pulled apart, air enters the steel at the grain boundaries, and a more or less heavy film of oxide forms around the grains which have separated. See Fig. 1. If not too much oxide is formed the grains may heal together (see Fig. 2), but the condition shown in Fig. 1 is typical of "burnt" steel. This condition cannot be cured except by remelting and floating out the oxide.

Whatever may be the underlying causes that render steels susceptible to heat cracking, the most expedient methods for preventing heat cracks in airplane construction consist in either eliminating or neutralizing the stress which is the immediate cause.

PREVENTION OF CRACKING BASED ON STUDY OF FORCES ENCOUNTERED IN WELDING

The prevention of cracking, therefore, is based on a

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Presented at the Fifth National Meeting of the A.S.M.E. Aeronautic Division, Baltimore, Md., May 12 to 14, 1931.

study of the forces which are likely to be met with in welding. Such forces may be classified in three groups: those which originate from the heat of welding, i.e., expansion on heating and contraction on cooling; those which in some instances reside or lie dormant in the metal and are released by the welding operation; and a third class which will be considered later.

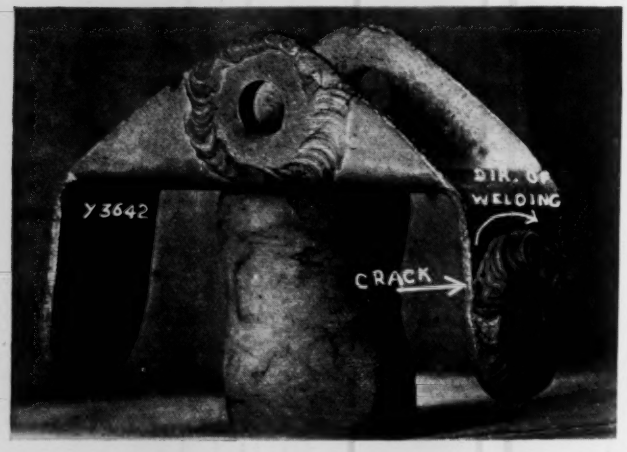


Fig. 3 Showing Location of Crack With Respect to Direction of Welding, Which in This and in All of the Examples of Edge Cracks, Figs. 3–12, Is Away From the Cracked Edge
(The remedy consists in welding toward the edge and in taking care not to overheat the edge.)

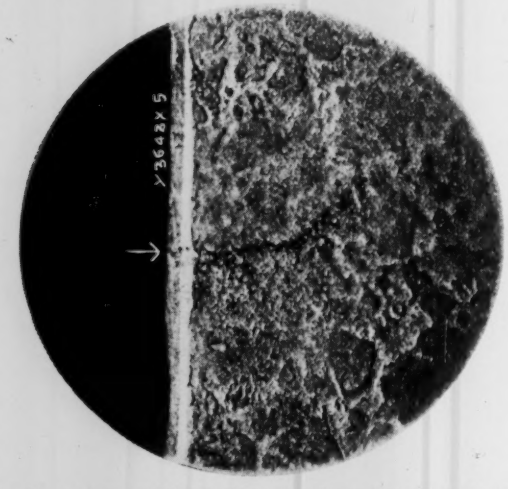


Fig. 4 Enlargement (×5) Showing Crack on Surface of Fig. 3 Opposite to That Welded
(In cases where the welding operation has circled around and finished where it was begun, the top surface of the crack is usually healed over by remelting. In this and the following examples it will be noted that the crack occurs at the junction of the base metal and the weld, where the section is thinnest and where the stresses that caused the crack are concentrated.)

Chrome-molybdenum steel is especially susceptible to heat cracking because the cracking stresses are intensified by its high strength and its susceptibility to air hardening.

The majority of cracks fall in the first group, typical of which is the edge crack. This has led to the saying, "don't edge weld," an unnecessary restriction.

Edge cracks usually occur in the base metal and follow the edge of the weld, but it is not for this reason that they are so termed. An edge crack is one which starts at an external edge of a part and follows the weld into the part.

It is a matter of common experience that when two pieces of sheet metal are butted together or when one is lapped over the other, they will come together in the one case, or move together scissors-like in the second case, when welded along the seam of the two edges. A crack is liable to start at the edge where the weld is begun. Typical examples are illustrated in Figs. 3–12, inclusive. The following analysis of the forces at work is advanced in explanation of the edge crack.

After the weld has progressed slightly from the starting point at the edge, two forces begin to operate, both tending to stretch the metal at the point where the weld was begun. One of these forces is produced by the contraction of the solidifying metal. This of itself would tend to produce a crack. Now, the weld metal just inside the starting point solidifies faster than the edge or starting point because of the more rapid conduction or subtraction of heat away from it by the adjacent metal. The air surrounding the free edge, or starting point, is a relatively slow cooling medium. Consequently, while the initial point at the edge is still at a white heat, the next interior stage has cooled to a yellow heat. In other words, the edge is lagging behind and is still in the tender or brittle condition while the adjacent stage along the weld is in the tough and ductile condition. This intermediate point acts as a fulcrum, so that the scissors-like action which brings the edges of the seam together tends to stretch the white-hot, brittle starting point of the weld. Moreover, as already stated, the shrinkage is also stretching the same point, and if the combined effect is great enough, a crack occurs.

It is not generally appreciated what a considerable contraction occurs when metal freezes and cools. Not considering the contraction of the cooling but molten weld metal, but starting at the moment of solidification, the metal shrinks about 5 per cent in volume in merely changing to the solid state. An additional contraction of almost 1 per cent then occurs before the temperature has fallen to a yellow heat. Another 1 per cent contraction takes place in cooling from a yellow heat to ordinary temperature. This sudden and considerable contraction is the cause of cracked castings, but it is only one of the stretching or cracking forces that must be intelligently controlled in welding. Figs. 13 and 14 illustrate a pure contraction crack. If the solidifying metal could stretch it would not crack; or, if the adjacent parts could yield, the contraction could be compensated.

Cracks Usually Located in Base Metal

Usually cracks are located in the base metal, right at the edge of the weld. There are several reasons for this. The principal reason for this particular location is that the section is thinner than the weld and its shape changes abruptly at this point. In the second place, the base metal, because of its nature, is usually

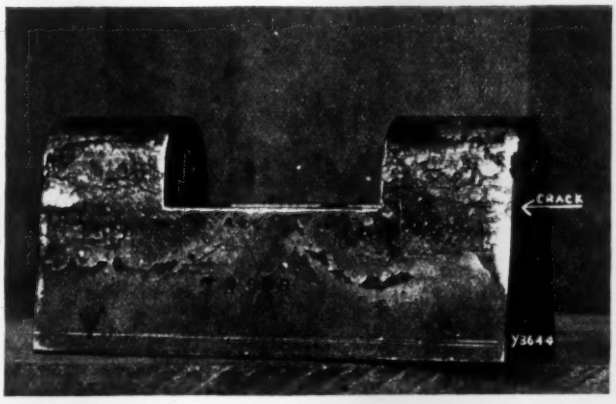
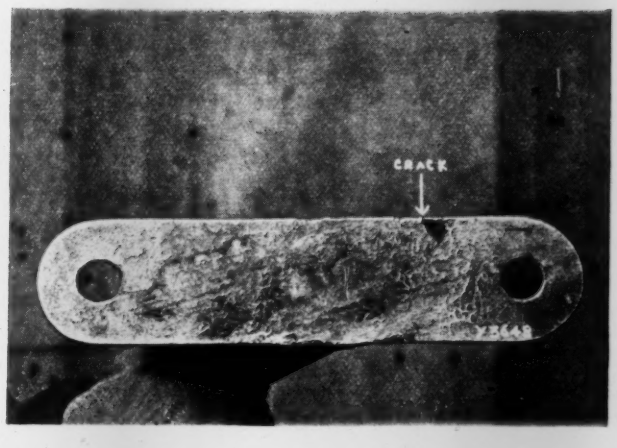


FIG. 5 GENERAL VIEW AND LOCATION OF CRACK AT EDGE



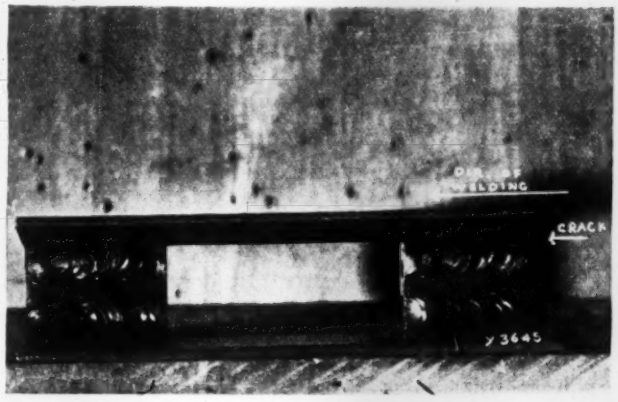
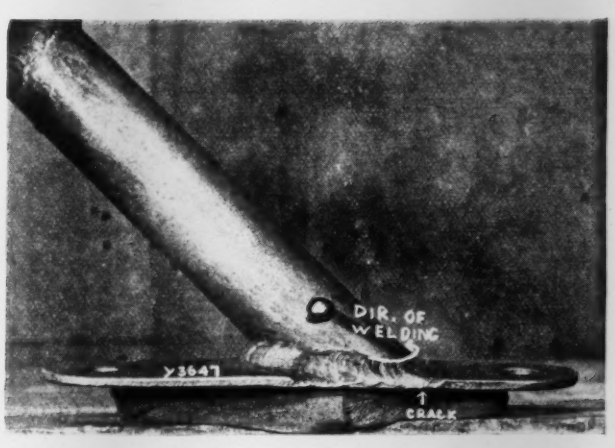


FIG. 6 BOTTOM VIEW OF FIG. 5 SHOWING DIRECTION OF WELDING TO BE AWAY FROM WELDED EDGE



FIGS. 8 AND 9 SHOWING BOTTOM AND SIDE OF WELD, AND DIRECTION OF WELDING WITH RESPECT TO LOCATION OF CRACK

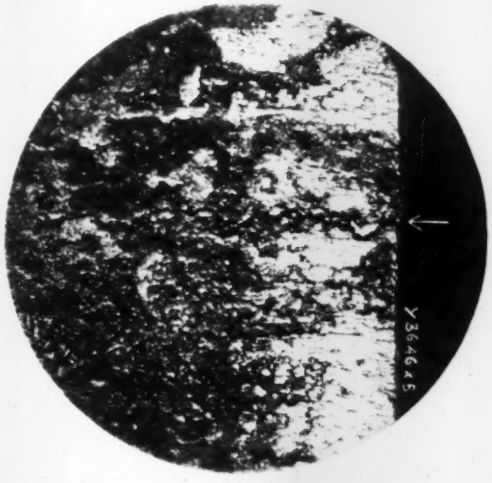


FIG. 7 ENLARGED DETAIL OF CRACK SHOWN IN FIGS. 5 AND 6 (×5)
(In this case the crack appeared on both surfaces because the weld did not return to its starting point. The previous bending operation probably had nothing to do with this case, because the crack occurred on the straight part of the side.)

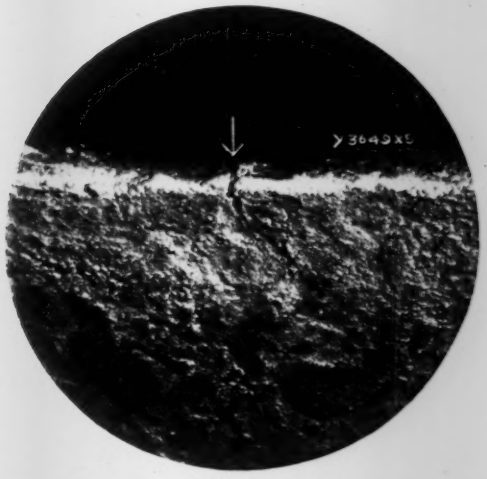


FIG. 10 ENLARGEMENT (×5) SHOWING CRACK IN FIGS. 8 AND 9 IN DETAIL

more tender at a white heat than the weld metal. Third, the thin section remains hotter—at least at the starting point on the edge—a trifle longer than the thicker, reinforced section of the weld. This is especially true of the lap seam, where the double thickness of base metal causes a more rapid cooling rate.

Sometimes the forces operating on a weld compensate or neutralize one another, and the net result

being zero, the metal is not stretched or cracked. That is, although contraction always takes place, there may yet be forces of compression exerted in the surrounding areas which squeeze the contracting area.

Fig. 11 Another Example of an Edge Crack

(Direction of weld the same as in the other examples, i.e., away from the edge which cracked. Here the weld passed down behind the edge, across the bottom, and up the opposite side. The farther edge, where the weld ended, was not cracked.)

Fig. 12 Enlarged Detail of Crack Shown in Fig. 11

On the other hand, external conditions or a combination of circumstances may be such as to exaggerate the cracking tendency. Again, the adjacent parts may be so rigid, either from their massiveness or because of being held immovable, that pure contraction occurs, resulting in a crack. These possibilities are represented in the sketches, Figs. 15, 16, and 17.

The reason for thoroughly analyzing these cases is that an understanding of the forces involved will lead to greater freedom in their control, for occasionally the matter is complicated by other factors, to be discussed later, and too simple rules, such as "weld toward an edge," may not be sufficient to prevent a crack.

One remedy for the edge type of crack is obvious and has been recognized and adopted by some: namely, to begin the weld at some point on the seam and weld toward an outside edge rather than to start at an outside edge and weld inward along a seam. A slight compensating compression is thus brought to bear on the weld.

While the designer can safely place a weld at an edge if the welder takes the proper precautions, it may yet be an inconvenience to the welder and slow down the operation for him to do so. In some cases it is possible and advisable for the designer to provide a little extra material, useless except as an expedient. The blueprint can indicate this and call for the surplus stock to be cut away after the weld is made. By a little foresight and cooperation it is thus possible on the one hand for the welder to take a little extra trouble and

Fig. 13 Showing Location of an Internal Contraction Crack at the Edge of a Fillet

Fig. 14 Enlarged View of Crack in Fig. 13 (× 2.5)

time where necessity requires it, and on the other hand for the designer to make it easier for the welder wherever possible and feasible.

While the full responsibility of avoiding heat cracks should rest on the welding operation, nevertheless, by an understanding of the principles involved, the designer can often assist in the ease and economy of the welding, though he need not be restricted in design.

CONTRACTION CHIEF CAUSE OF HEAT CRACKS

The force of contraction is probably the chief cause of heat cracks, particularly the edge crack. The contraction of the solidifying metal sometimes causes a crack in the interior of the work, away from an external edge, but this is rare. Another type of internal heat crack is more common and will be discussed later. The direction of welding seldom has anything to do with the interior contraction crack. Several ways of preventing the interior contraction crack may be employed. As a rule these expedients operate by exerting a slight compression on the weld. Sometimes this can be conveniently done by heating nearby parts, thus expanding the intervening metal and causing it to press on the weld. Sometimes a mechanical clamp is useful. In both cases care must be taken not to compress the weld enough to buckle the soft metal. Merely preheating adjacent parts may be sufficient. This not only exerts a slight compression but it retards the rate of contraction of the weld. It also softens the adjacent parts and allows the metal to pull in and compensate for the contraction. The choice of expedients will depend on the individual case.

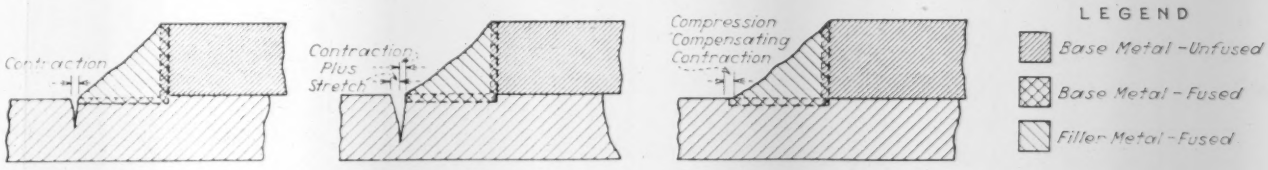


Fig. 15 Pure Contraction of Fused Metal

Fig. 16 Contraction of Fused Metal Plus Stretch of Base Metal

Fig. 17 Contraction Compensated by Compression

FIGS. 15–17 CAUSES AND PREVENTION OF CRACKING AT A FILLET WELD—DIAGRAMMATIC ANALYSIS

Before going on to other sources of cracking forces, it may be well at this point to consider the effect of the melting that necessarily accompanies welding on the occurrence of heat cracks. It has long been known in steel founding that the melting procedure and the casting temperature vitally affect the tendency of a casting to develop heat cracks on solidifying. It is known, for example, that well "killed," that is, deoxidized, metal is less liable to crack than "wild" or oxidized metal. Furthermore, to assist in avoiding cracks the steel melter pours his metal as near to the freezing point as is feasible.

Parallel procedure is advisable in welding. All welders know that it is easier to overheat an edge than an interior area. Overheating is one of the supporting causes for the edge crack. And so if extra care is taken in this respect when welding at an edge, it will assist materially in preventing cracks; but refraining from overheating will not of itself eliminate cracking. The use of special rod metal is also helpful in this respect, by virtue of certain beneficial ingredients incorporated in the rod which help to deoxidize the weld. In aircraft welding, partly because of the thin sections usually dealt with and partly because of the wide use of special steels, only a barely visible "feather" of excess acetylene at the most should be used. This will insure that the flame is at no time even slightly oxidizing, as may occasionally happen when an attempt is made to hold to the "neutral" flame. Gas regulators should be in the best possible working condition for aircraft welding so that the desired flame adjustment can be maintained steadily.

PREVENTION OF CONTRACTION CRACKS

Summing up the foregoing discussion on the prevention of contraction cracks: Avoid superheating the metal much above its melting point. (Heat just enough to permit fusion to take place, always being certain that thorough fusion is obtained.) Use extra care at edges: this can be done by withdrawing the flame somewhat on approaching an edge, or by speeding up the operation. Another means, not mentioned before, for protecting an edge is to lay it against a heavy section of metal. Use a strictly neutral or slightly excess acetylene flame—never let it become oxidizing. Compensate for contraction forces by welding toward an edge instead of starting at an edge, or by preheating or by clamping or other means of placing the weld in slight compression.

So far the discussion has included only one type of cracking force: that which is due to or induced by the welding operation itself, that is, the force of contraction of the solidifying and cooling metal, while it is yet white-hot, and the similar forces of expansion and contraction in the metal affected by the welding heat. There are two other general classes of cracking forces. A crack may be caused by only one type of cracking force; on the other hand, it may be the net effect of a complexity of forces.

The second class of cracking forces includes those which are sometimes present in the metal before welding begins. These are the forces resulting from previous cold work, such as rolling, bending, straightening, etc.; also the forces induced by previous heat treatment. Such forces are exaggerated by certain compositions. These forces sometimes place the metal in tension, like a bent bow or a taut bowstring. Then, where a part is softened by the welding, it is stretched

asunder by the tension in the adjacent sections. An example of this class is illustrated in Figs. 18 and 19.

PREVENTION OF CRACKS IN METAL STRESSED BY PREVIOUS OPERATIONS

When a weld is to be made in metal that is known to be in a stressed condition, it is expedient before welding to remove the stresses from the areas adjacent to that which is to be welded. This is an effectual safeguard. It is easily accomplished by a preliminary heating to a just visible red heat, taking care not to heat to a bright red. This is a practice somewhat different from that of preheating. Even when working with metal supposed to be in a fully annealed condition, local stresses due to the effect of previous cold work, as in straightening or bending, are likely to be met with.

As an example of this method of preliminary heating, take the case of a large assembly of chrome-molybdenum tubing in a truss structure. The tubing is in the heat-treated condition (ultimate strength about 125,000 lb. per sq. in.) and the main members are long and of elliptical cross-section. Diagonal tubes of smaller and circular section are welded at intervals to the main members.

FIG. 18 FRONT AND SIDE VIEWS OF A WELDED SEAM

(Front view (at right) shows cracks running left and right from seam about one-quarter length down from top of weld. This is a different class of crack from those previously shown. It is caused by stresses set up in the metal by previous operations. In the present case the swaging operations or the welding of the adjacent seams, if this was done first, tended to make the metal like a bent bow (see view at left), so that when softened by welding the white-hot metal cracked. The remedy in such cases is a preliminary heating of the affected metal to a dull-red heat.)

FIG. 19 ENLARGEMENT GIVING DETAILS OF CRACKS IN FIG. 18

(Although these cracks run from the edge they are not classed with edge cracks because the predominating causes are stresses from prior operations.)

Sometimes cracks occur at the edge of the welds and sometimes they do not. It is neither a case of edge cracking nor of pure contraction. The main tubes are in an irregularly stressed condition due partly to the previous heat treatment and partly to the straightening. If the weld happens to be located at an area where the metal is under tension, like a taut bowstring, from previous work or heat treatment, a crack will occur. The designer counts on a final strength at the joints of, say, 95,000 lb. per sq. in., the reduction being due to the heat effect of the welding operation. Nevertheless the higher strength remaining in the sections of the tubes between the welds is desirable. But since only 95,000 lb. per sq. in. is required at the joint, the tubing may be given a preliminary heating, to a dull red, around its entire girth at the place where the weld is located, and this heating will not affect the designed strength. Of course where a final heat treatment is possible a preliminary heating is equally permissible. The only effect of raising steel to a dull-red heat is to remove the internal stresses from previous cold work or heat treatment; it does not recrystallize the metal or air

harden it. The prescribed treatment is momentary, such as can be done by passing the blowpipe slowly around the tube. The preliminary heating does not need to be maintained during the welding operation, and differs in this respect from preheating.

Another means of preventing cracks in metal which is in a previously stressed condition is to enclose the part in a clamp suitably constructed so as not to buckle the softened metal but with just enough restriction, properly applied, so that, when the metal is softened by welding, the adjacent areas are supported and movement prevented. Both of these methods apply equally well to parts that have previously been either heat treated or cold worked.

Another common "don't" for the designer and welder is, "don't weld on opposite sides." The reason for this admonition is that the stresses of expansion or contraction or air hardening induced by the first welding operation are apt to cause cracking in the second operation. Furthermore the initial melting renders the steel more susceptible to cracking. This type of crack falls under the second class, i.e., where the stress from some previous operation is latent. As a matter of fact, one fillet weld on one side of a member is usually ample and the designer may well be guided by the above "don't," but wherever it is really needed the welder should feel confident of being able to make the second weld in safety by taking the precautions required for this type of stress.

Still another type of cracking force has to be reckoned with which has nothing to do either with the welding itself or with the metal. This type of stress is external to the weld area. Sometimes a stress occurs in the white-hot metal because of careless or rough handling, or the improper application of jigs and clamps. The remedy in such instances is usually obvious. This possibility should be kept in mind when conducting an examination of a cracked part whose previous history is unknown.

As a final summary: The prevention of heat cracks is not difficult at the most, and the procedure necessary to employ is greatly simplified by the fact that practically all cracks fall into two main groups: the edge crack, which predominates, and the crack caused by some internally stressed condition of the metal. A simple expedient suffices to prevent each type of crack: for the edge crack, welding toward the edge; and for the other type, a preliminary heating to remove latent stresses. Auxiliary expedients and precautions may apply to individual cases.

A British Steamboat Pioneer

A CENTURY has now passed since William Symington, the Scotch engineer and inventor, died in the East of London. His work as one of the pioneers of the steamboat, as the first British engineer to build a marine engine, and as the first of all the pioneers to produce a really reliable and practical steamboat, had brought Symington little but loss and disappointment, and in the end he died poor and almost forgotten.

Symington was born in the mining village of Leadhills, Lanarkshire, in 1763, and was therefore 67 years old when he died. He was probably one of the best-known mining engineers of his day, and much of his work was, no doubt, done in the mines of Scotland. The facility with which, on two occasions, under entirely different circumstances, he solved the problem of propelling a boat by steam, is ample evidence that he possessed inventive powers of no mean order.

To appreciate justly the efforts of the pioneers of the steamboat it is absolutely essential to remember the circumstances under which they worked. The most active of the pioneers, strangely enough, were in America, where there were neither engineering works nor any considerable number of steam engines, and to which the export of machinery from England was forbidden. On the other hand, all British inventors were faced with the necessity of avoiding the wide ramification of Watt's famous patents, in itself no small task. The patents of Watt not only included the separate condenser, but expansive working, double action, and various devices for obtaining rotary motion. Inventors were likewise denied the use of the crank. If these things are taken into consideration our interest in Symington's two engines is heightened, for the 1788 engine was built while Watt's patent was in force and the 1902 engine after it had expired. The engine of 1788 had open-topped cylinders like Newcomen's engines; an extension of the cylinder acted as a condenser, and for obtaining rotary motion Symington devised the arrangement of rods and chains, pulleys, and ratchets, which any one may examine for himself on the engine at the Science Museum. Symington's engine for the *Charlotte Dundas* was entirely different from that of the engine of 1788. Free to utilize the work of others, he designed an engine with a single double-acting cylinder, the piston rod of which drove the crankshaft of the paddle wheel direct through a crosshead and connecting rod. In the *Charlotte Dundas* the cylinder was placed horizontal with the condenser and air pump below, but in his patent of 1801 Symington had stated that the cylinder might be used "in a perpendicular position or any of the different angles between a perpendicular and horizontal position as circumstances may require." His engine was a remarkable piece of work, and though our early steam vessels and steam warships were fitted with an immense variety of engines, in 1858 an Admiralty Committee, probably knowing nothing of Symington's patent, declared that the most suitable engine for naval vessels was the single-piston-rod engine with crosshead, connecting rod, and crank. With the cylinder horizontal as in the *Charlotte Dundas*, or slanting as in the diagonal paddle-wheel engine, or vertical as in all modern reciprocating marine engines, Symington's type of engine is known to tens of thousands of engineers, most of whom, however, are probably ignorant of its origin.—*Engineering*, March 20, 1931, pp. 384–385.

Testing Dry Air Vacuum Pumps

Description of a Method by Which the Conditions Existing in Condenser Practice Are Met and Accurate Results Showing the Characteristics of Air Pumps Are Obtained

By HARWOOD F. MULLIKIN,[1] BALTIMORE, MD.

THE testing of dry air pumps used for the evacuation of air and non-condensible vapors from condensers offers a problem of considerable difficulty. To determine the exact amounts of air handled and the steam consumption at predetermined conditions is not as easy as it might seem.

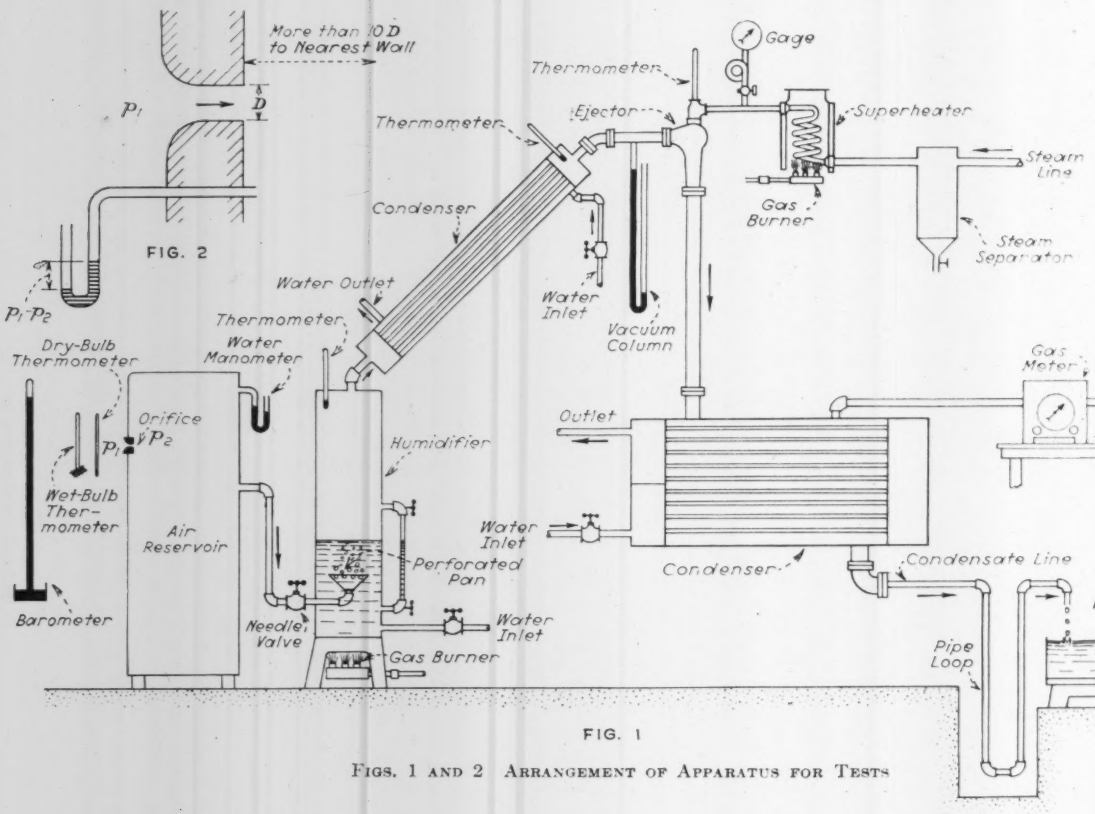


FIG. 1

FIGS. 1 AND 2 ARRANGEMENT OF APPARATUS FOR TESTS

Advantage cannot be taken of commercial condenser installations since it is desirable to vary the conditions of operation in order to obtain characteristic curves of the air pump. It would be very difficult, if not impossible, to vary the steam pressure used on the pump, the amount of air to be exhausted, and the condenser vacuum, at the same time adequately measuring these quantities.

It would therefore appear that air-pump testing is essentially a laboratory problem and that special apparatus must be evolved. The necessity for the latter may be shown when we consider the conditions under which air vacuum pumps operate.

The air being exhausted must be 100 per cent humid, since this is the state of the air evacuated from a condenser. The pressure and condition of the steam used should be a matter of close measurement. There must be no moisture in the steam. To assure this a few degrees of superheat are desirable.

Testing of dry air pumps has received but little attention from investigators. Redfield, in a paper entitled "Capacity Tests of Dry-Vacuum Pumps by the Low-Pressure Nozzle," presented May 23, 1921, at the A.S.M.E. Spring Meeting in Chicago, advocated various ideas on the subject. He measured air flow by means of nozzles. Modern researches have developed more accurate formulas than he used, and the fact that he concerned himself only with the action of a dry air pump working as a compressor using air at atmospheric humidity, instead of the mixture of saturated water vapor and completely

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Presented at a meeting of the Baltimore Section of the A.S.M.E., Baltimore, Md., May 10, 1930.

humidified air encountered in the actual condenser, renders the results inaccurate, which was ably pointed out by A. H. Blaisdell in the discussion.

The inaccuracy of the Redfield method was also discussed by Noyes and Sturtevant in their paper "The Size of Dry-Vacuum Pump to Employ in a Given Case," presented at the Annual Meeting of the A.S.M.E. in December, 1922. Their paper, however, is concerned primarily with the air exhaustion of closed vessels and is wholly inapplicable to condenser air-pump practice.

It is proposed to describe a method by which the conditions mentioned as actually existing in condenser practice will be met, and accurate results showing the characteristics of air pumps obtained. The following method has been worked out and tried by means of apparatus which has been set up in the Johns Hopkins University laboratory. It appears to give very good results.

As suggested by Redfield, it is proposed to measure the volume of air flowing by means of a nozzle as shown in Figs. 1 and 2. Since the air flow is to be variable, a low-pressure nozzle working above the critical pressure must be used. A word explaining the reason for this is probably quite advisable.

The critical pressure for air is 0.53 of the initial pressure. If the back or final pressure is below this value, the total expansion ratio is high and the term "high-pressure" nozzle is employed. If the final pressure is above 0.53 of the initial pressure, the expansion ratio is relatively low and a "low-pressure" nozzle results.

It is fundamental in the theory of nozzles, explained in every textbook on thermodynamics, that if the back pressure is below the critical pressure the area of the throat fixes the discharge, expansion beyond the throat having no effect on the discharge. Hence if a high-pressure nozzle were used, only a fixed quantity of air, determined by the area of the throat, could be passed unless the initial pressure was varied. In air-pump work this initial pressure is always atmospheric since the intake is from the atmosphere, hence this type of nozzle presents obvious disadvantages.

On the other hand, in the operation of a low-pressure nozzle where the back pressure is above the critical, the flow is determined by the back or final pressure. If the pressure difference is small, a small quantity will flow. If the pressure difference is large, a large quantity of air will flow. In the layout shown the air passes from the atmosphere through the orifice and into the reservoir, the pressure difference being but a few inches of water. Hence the reservoir pressure is nearly atmospheric, being therefore well above the critical pressure.

Modern and accurate formulas for air and gas flow have been developed by S. A. Moss, of the Thomson Research Laboratory, and incorporated in a paper entitled "Measurement of Flow of Air and Gas With Nozzles," presented before the A.S.M.E., December 5, 1927.

In addition to a general discussion of the properties of air, Mr. Moss has offered formulas for air measurement by means of orifices under various conditions. As stated before, it has been found more accurate and more advisable to work with a pressure in the reservoir of but a few inches of water less than atmospheric, hence the formula for the case where the differential pressure is less than 10 per cent of the initial pressure is used. It is:

$$w = 157.6\, Ac \sqrt{\frac{G(P_1 - P_2)P_2}{T_1}}$$

where w = air flow through nozzle, lb. per sec.
157.6 = a conversion factor
A = area of nozzle, sq. ft.
c = coefficient of discharge. For a nozzle with well-rounded approach as shown in Fig. 2, it may be taken as 0.97 for nozzles with diameters less than 1 in.; 0.98 for nozzles to 2 in. in diameter; 0.985 for nozzles to 4 in.; 0.99 for nozzles to 12 in.; and 0.995 for nozzles above 12 in.
G = a factor depending on the humidity of the air. May be taken as 1.0 for ordinary work. For very accurate work see the table in Moss's article
P_1 = initial pressure, lb. per sq. in. abs.
P_2 = final or reservoir pressure, lb. per sq. in. abs.
T_1 = abs. fahrenheit initial air temperature.

The foregoing explanation of the nozzle has been rather extended, but the nozzle is probably the most important part of the apparatus. In addition, it may be noted the nozzle should be absolutely smooth and polished.

Referring again to Fig. 1, the location of the wet- and dry-bulb thermometers to determine the humidity is shown. The air passes from the atmosphere into the reservoir. A water manometer measures the pressure difference. The air is withdrawn through the line shown and the flow is controlled by a needle valve. It bubbles through the heated water in the humidifier, where it becomes saturated with moisture.

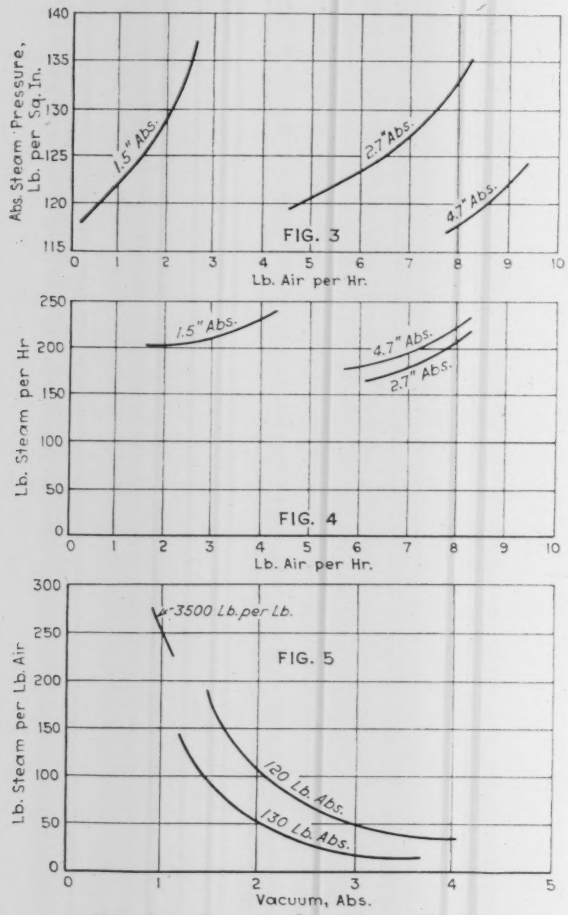
Since a vacuum exists in the humidifier the air is readily drawn through the needle valve, the only function of the latter being to pass any quantity of air desired as measured by the orifice. The temperature of the humidifier is kept about ten degrees above that corresponding to the vacuum pressure. The heated humidified air next passes into the inclined condenser where its temperature is lowered to that corresponding to the vacuum pressure. This condenser cooling is resorted to in order to obtain complete saturation of the air. The inclination permits condensed moisture to flow back into the humidifier.

The air is now 100 per cent saturated and at vacuum pressure—conditions corresponding to those existing in a condenser. It next passes to the air pump. In

the figure a steam air ejector is shown since this was the type of pump tested by the author; however, any type of pump, including the reciprocating types commonly used, may be inserted here and tested with equal facility.

The steam with the entrained air now passes into a condenser where it is condensed and weighed.

The steam used should, of course, be at a known condition. In the test described, steam is passed through a steam separator to remove any moisture that might be present. A small superheater is installed to superheat the steam one or two degrees so that absolute dryness will be assured. A pressure gage records the pressure.



FIGS. 3–5 RESULTS OBTAINED IN TESTS

The air ejector used in this test being relatively small, it was deemed advisable to measure the air by means of a gas meter in order to check the accuracy of the orifice. To this end the top of the condenser shell was tapped and an air line led off to a gas meter. A loop in the condensate line was then installed owing to the fact that a slight pressure of several inches of water was needed to operate the gas meter.

Because of the larger-sized units used in commercial practice, the orifice method of measuring air is the only one that can be employed, the gas meter being out of the question.

The curves of Figs. 3–5 show some of the results obtained on the unit tested. From them the necessity of knowing the characteristics of any pump so that it can be operated at conditions of highest efficiency can readily be seen.

In Fig. 3 it is seen that the pump should be operated at a certain pressure for any given vacuum. This is most important in a practical installation in order to obtain high efficiency. As is to be expected, the quantity of air exhausted increases as the vacuum decreases. It also follows that the steam rate per pound of air will be lower at the lower vacuums, which is seen from Figs. 4 and 5.

Fig. 5 shows the great influence which different steam pressures may have on the steam consumption as discussed before.

The curves vary for the different types and sizes of pumps; but the necessity of tests to obtain these curves, as well as the method and apparatus for testing, have, it is hoped, been amply shown.

The Maier Form of Hull Construction

TWENTY-FIVE vessels of the "Maierform" type have already been built, comprising a large variety of types and sizes ranging from 700 tons to 20,000 tons displacement. The Maierform originated, and was evolved, from the early experiments of the late Austrian scientist, Mr. Maier. His experiments led him to the belief that, in a vessel of normal form, particles of water encountering the bow passed over the surface in their passage to the stern in a path which, if projected on the body plan, produced a sort of serpentine curve. From these observations he concluded that if the form could be so altered as to produce a path that would appear on the body plan as a more or less straight diagonal, the path would be shorter and the resistance less.

To test the validity of his theory, Maier selected the best normal form he could secure, and in adapting it to Maierform he took care to preserve the same dimensions, displacement, block coefficient, etc., so that the models were, to all intents and purposes, absolutely identical with the sole exception of the form of the lines. In comparative tests in the Vienna tank with these models he obtained a reduction in resistance for Maierform of about 10 per cent. The wetted surface of a Maierform vessel is inherently about 2 per cent less than the wetted surface for a corresponding normal form, so it was quite evident that the reduction in resistance obtained could not be explained by a reduction in frictional resistance alone, and that the difference must be sought in a decrease in wave-making resistance or in eddy resistance, or in both. Subsequent tests confirmed the results of Maier's original experiments, the reduction in resistance reaching 12 per cent.—M. F. May in an Institute of Naval Architects' paper abstracted in *The Engineer*, April 3, 1931, p. 369.

Economic Aspects of Industrial-Casualty Reduction

By L. W. WALLACE,[1] WASHINGTON, D. C.

FOR a three-year period, ending June 30, 1929, the average annual number of compensated accidents for which awards were made in New York State was 97,670. The number of actuarial-accident weeks for which compensation was paid was 2,421,922, which is the equivalent of 46,575 actuarial-accident years. In the same three-year period the average annual compensation paid was $29,437,298, making a rate of $2.26 per capita per year for the state of New York.

Mr. John T. Ryan has shown that the days lost due to mine accidents in the coal industry of Pennsylvania, for the first six months of 1930, were equivalent to 46,036 actuarial-accident years. He estimated the loss in wages due to the accidents to be $48,798,530—a rate of approximately $5 per capita for the six-month period for the state of Pennsylvania.

There are 31,000 people killed in automobile accidents in the United States each year. It has been estimated that the economic loss from these accidents and the congestion of traffic combined, totals three billion of dollars annually—a rate of $24 per capita per year. If these 31,000 fatalities were capitalized at $5000 each, the amount fixed by the compensation laws of some states, they would represent a capitalization of $155,000,000.

The unfortunate thing is that more industrial executives do not fully appreciate the economics involved. This is perhaps due to the fact that the economic phase of accident-prevention work has been unduly neglected by the leaders of the safety movement. It is undoubtedly true that had the same emphasis been placed upon the economic as upon the personal-injury phase, greater accomplishment would have been realized by the safety movement. If the safety movement is to expand and intensify as it should, industrial executives will have to be more generally aroused. This can be brought about by making them realize that accident-prevention work is not only important because of human values but also because of the tremendous monetary values involved. This does not mean that industrial executives are unmindful of and unsympathetic to humanity. They have spent large sums because of their consideration and sympathy. It merely means that from a purely dollars-and-cents point of view accidents are so costly that they demand the personal attention of industrial executives. And unless industrial executives assume their full responsibility with regard to the prevention of accidents, there will continue to be enormous economic loss.

The Large Economic Loss Associated With Accidents

These few examples clearly disclose that there is a very large economic loss associated with accidents. No one knows the aggregate for all the accidents which occur in the United States annually. That it is enormous there can be no doubt. It is perhaps one of the very heavy economic drains upon the nation, to say nothing about the social and spiritual values involved.

The large economic losses shown clearly indicate that there is an economic aspect of accidents. Since this is true, the converse is also true, that there are economic aspects of accident prevention. Indeed it is obvious that there is a close relationship, and to Mr. Sidney J. Williams must be given the credit for having clearly pointed it out. Some years ago he said, in effect, that efficiency of operation implies the performance of a task in "the one best way." This means that every phase of the task has been carefully analyzed and in the light of the analysis a procedure established which insures the economic performance of the task repeatedly. As long as nothing interferes, the performance may continue indefinitely without loss of efficiency. However, it frequently happens that something unexpected occurs which interferes with regular performance, and hence inefficiency results.

Since by definition an accident is something unexpected—an interruption of ordinary routine—anything which causes an interference, a drop in performance, may be termed an accident. This is a point of view which places emphasis upon the economic aspects of accident-prevention work. It has been customary to consider an accident as having occurred only when some personal injury has resulted. But in the light of the thought expressed by Mr. Williams, there may be many accidents, many interruptions of an orderly routine, without a personal injury resulting therefrom. It is easy to understand that the economic losses associated with non-personal-injury accidents may be very large indeed. Such losses may exceed those where personal injury is involved. From an economic point of view, therefore, it may be far more important to ascertain the causes of such accidents and to remove them, than to avoid a personal injury, however laudable and desirable that procedure may be. It must be remembered that all accidents are interruptions to an orderly procedure and are therefore potential human hazards; hence in no sense do we underrate the human phase of the problem when we emphasize the economic aspect. In emphasizing the economic aspects of accidents we ap-

[1] Executive Secretary, American Engineering Council. Mem. A.S.M.E.

Presented at the Annual Meeting, New York, December 1 to 5, 1930, of The American Society of Mechanical Engineers.

preciate that as a recognition of its importance grows, better prevention work will be done and more human lives will thereby be saved.

Accidents Indicate Interference With Orderly Procedure and Therefore Expense

An accident should be looked upon as a danger signal indicating that there is something interfering with orderly procedure and therefore costing money. If this thought should prevail, the prevention of accidents would then be recognized as a more important matter than it is now generally regarded. A recognition of the relationship of accidents and efficient production led the National Bureau of Casualty and Surety Underwriters to make arrangements with the American Engineering Council whereby a study of safety and production was made. The Council was requested to endeavor to ascertain the truth of the generally accepted but unproved thesis that the safe factory is an efficient factory, and that an efficient factory is a safe factory. A large body of data was obtained which threw much light on the relationship between accidents and the rate of production.

The findings of the report "Safety and Production" issued by the Council were based upon the experience of 20 industries and 60 product groups, with an exposure of over 50 billion man-hours. The report shows that by using the word "safe" to express decreasing accident rates, and the word "productive" to express increasing production rates, among unsafe factories there were only ten (measured in number of employees) which were "productive," whereas there was only one "unproductive" among the "safe" factories—a ratio of 109 to 1. This may be paraphrased by saying that a "safe" factory is eleven times more likely to be "productive" than is an "unsafe" factory. It was found that the plants which had made the greatest progress in accident prevention had also made the greatest progress in productivity.

There were not sufficient comparable data obtainable to show a conclusive mathematical correlation between accident and production rates. However, there was such a preponderance of evidence as to justify the conclusion that a safe factory is an efficient factory and an efficient factory is a safe factory. This conclusion and all the facts associated with it thoroughly justify the statement that accident-prevention work will result in large, measurable savings. Many companies over many years have realized large net savings on their accident-prevention work. Only a few examples will be cited in this discussion.

Savings Made Through Accident-Prevention Work

A group of paper mills has had the following experiences:

Company A, through intensified accident-prevention efforts over a two-year period, reduced its insurance rate from 41 to 26 cents.

Company B, through similar methods over a three-year period, reduced its insurance rates from 77 to 24 cents.

Company C, over a six-year period, reduced its rates from $1.66 to 66 cents.

A chemical-manufacturing company had the following experience with respect to its lost-time accident-frequency rates: In January, 1927, when the first foremen's meeting was held to give consideration to the prevention of accidents, the rate was 24. At a meeting of the foremen in January, 1928, the rate was 9.5, and in January, 1929, it was 8. Through the efforts of the foremen the lost-time accident-frequency rate was reduced $16^2/_3$ per cent in ten years.

Three years prior to 1928 the accident-severity rate of a crushed-stone company was 6.9. Early in 1928 a reorganized effort was directed toward reducing the rate. By September 1, 1930, the rate was 4.7, a reduction of 31 per cent. Prior to inaugurating the improved accident-prevention work, the frequency rate was 51.6, and on September 1, 1930, was 30.3, a reduction of 40 per cent. The improved accident-prevention work reduced the cost of compensation and medical attention 60.5 per cent.

Examples Showing That Organized Safety Work Pays

Recently Mr. Blakeslee, of the National Safety Council, cited the following as actual examples of the value of instituting industrial-safety programs:

In 1918 a plant employing 4000 men spent $175,000 for industrial accidents, or about $44 per man. In 1928 this same plant spent only $30,000 for industrial accidents, including the cost of its safety department, or about $7.50 per man on the payroll.

Another company reduced its industrial-accident cost from about $30 per man on its payroll in 1926 to less than $7 in 1928.

Recently the core plant of the Wood Mosaic Company, Louisville, Kentucky, won a trophy because it had reduced its accident cost per $100 of payroll from 14 cents in 1928 to less than 6 mills in 1929.

The Wheeling Mould and Foundry Company, of Wheeling, West Virginia, during the fiscal year ending June 30, 1929, through organized safety work, made a saving of $41,000 in hospital charges and compensation for that year. The reduction in the accident cost from the previous year was 71.8 per cent.

In January, 1927, the Building Trades Employees' Association of New York City began to develop and promote safe methods and practices. Recently this association was commended by the State Compensation Inspection Rating Board after having made two reductions in the workmen's-compensation insurance rates in 1929. These reductions amounted to an average of 18.8 per cent on 32 building trades classifications. These reductions meant a saving in premiums to the state's industry of over $2,700,000.

The foregoing examples, which could be greatly extended in number, conclusively show that organized safety work pays. They clearly disclose that there is

a very definite and real economic phase of industrial-casualty reduction.

EXECUTIVES MUST BE AROUSED TO IMPORTANCE OF SAFETY WORK

The unfortunate thing is that more industrial executives do not fully appreciate the economics involved. This is perhaps due to the fact that the economic phase of accident-prevention work has been unduly neglected by the leaders of the safety movement. It is undoubtedly true that had the same emphasis been placed upon the economic as upon the personal-injury phase, greater accomplishment would have been realized by the safety movement. If the safety movement is to expand and intensify as it should, industrial executives will have to be more generally aroused. This can be brought about by making them realize that accident-prevention work is not only important because of human values but also because of the tremendous monetary values involved. This does not mean that industrial executives are unmindful of and unsympathetic to humanity. They have spent large sums because of their consideration and sympathy. It merely means that from a purely dollars-and-cents point of view accidents are so costly that they demand the personal attention of industrial executives. And unless industrial executives assume their full responsibility with regard to the prevention of accidents, there will continue to be enormous economic loss.

If I should presume to suggest to experts in the field, my suggestion would be to direct greater attention toward collecting and disseminating facts as to the economies to be realized through accident-prevention work, the major purpose of such an effort being to impress upon industrial executives that it is a matter of such large and important dimensions as to demand their personal continuing attention and direction. If this be accomplished, then the safety movement will gain greater momentum, from which will be garnered tremendous economic and human values.

Discussion[2]

"THE steel industry is trying to meet its obligation to labor by making certain that all new construction is designed correctly from both a safety and productive standpoint," said Martin J. Conway, fuel engineer, Lukens Steel Company. "Modern plants and machinery incorporate both strength and safety, but 'weak spots' should be looked for in the older parts of the plant."

"To eliminate unsafe practices and designs at the plant of the Lukens Steel Company," Mr. Conway said, "one departmental safety patrolman is appointed for each eight men employed." These men are selected for their intelligence and ability to observe quickly. They meet monthly and report unsafe places observed. It is found that measures to prevent accidents are made best and quickest through sympathetic consultation. As a result the number of lost-time accidents was reduced 61 per cent in 1930 as compared with those occurring in 1929, and the number of compensation cases was reduced 47 per cent. The departmental safety patrolmen are rotated twice yearly so as to bring "fresh eyes" on the inspection work.

UNSAFE PRACTICES HAVE PRACTICAL REMEDIES

In commenting on the control of industrial-accident frequency, H. W. Heinrich, assistant superintendent, Engineering and Inspection Division, The Travelers Insurance Company, said that this is the responsibility of business management. Research shows that the estimate that 98 per cent of industrial accidents are preventable is conservative. A 50-per cent reduction can be achieved with little expense and with existing executive machinery. The causes of industrial accidents are the same as those of defects in quality and decrease in production. Mr. Heinrich gave two examples to illustrate this. Among the causes of accidents which he listed are: Disregard of instructions or instructions not issued, poor discipline, unnecessary haste, inexperience, mechanical defects, congestion, improper processing of operations, and poor layout of machinery.

The difficulty of getting foremen and employees to work safely, he said, lies in lack of facts regarding unsafe practices and conditions, insufficient information concerning the reason for certain practices and conditions, and failure to understand the supervisory function as applied to the enforcement of safe practices. An employer who recognizes his responsibility for the safety of his workers will see that any unsafe conditions are eliminated, just as he would if insubordination or carelessness of employees resulted not in accidents, but in delays, spoilage, breakage, defective merchandise, or low production.

The ratio of accidents to severe injuries is 300 to 1. The 300 accidents which do not cause injuries do not include the millions of slips, fumbles, and errors, but include narrow escapes, as when a man falls from a ladder and is not hurt. If managers, executives, and supervisors will think of accidents in terms of unsafe practices and conditions, and determine the reasons for their existence, they will seldom be in doubt as to a practicable remedy.

ACCIDENT CAUSES SHOULD NOT BE CONFUSED WITH RESULTS

Confusion of the cause of an acident with the result of the accident or the cause of injury was discussed by Hugh S. Hanna, U. S. Bureau of Labor Statistics, Washington, D. C. He said that the item "fall of worker" is often given as the cause of an accident. This is really the cause of the injury, and the cause of the accident

[2] Brief summary of discussion at the Symposium on Industrial-Accident Prevention, A.S.M.E. Annual Meeting, Dec. 1 to 5, 1930. In addition to the preceding paper by Mr. Wallace, two others were presented, namely, "Engineering Revision an Essential Factor in Accident Prevention," by Lucian W. Chaney, and "Management's Responsibility for Industrial Accidents," by L. P. Alford. These papers were published in the December, 1930, issue of MECHANICAL ENGINEERING, on pages 1045–1050.

may have been a slippery floor, a dark corridor or workroom, or a misplaced board or tool. Again, "falls of roof" are listed as an important cause of coal-mine fatalities. The fall of the roof is the cause of the injury, and it in turn is the result of an accident. The cause involves questions as to why the roof should fall. It may have been due to bad timbering, improper inspection, or carelessness on the worker's part.

Results from 25 years of safety work have been disappointing. The earliest scientific attempt to estimate the number of fatal industrial accidents, which was made in 1913, placed the number at about 25,000 per annum. The most recent estimates employ the same figure.

One of the important reasons for this unsatisfactory record, in Mr. Hanna's opinion, is that accidents are thought of in terms of individual responsibility or blame. Effective accident-prevention work is primarily, and perhaps solely, the result of profiting by experience. The management is the only one of the parties concerned that can profit to any important degree by experience. It is a continuing organization and can stand off and study accidents impersonally. The individual worker cannot do this as he meets with but few accidents, and with but one fatal or serious accident. Fellow-workers cannot be expected to profit very much from accidents in which they are not personally involved. It is therefore essential that complete social responsibility for accidents be assumed by management, because it is the only agency from which effective safety work can be hoped for. The workmen's compensation acts did this in regard to the employer's financial responsibility for accidents. The safety movement must do the same thing in regard to the obligation to prevent accidents. This attitude is not a defense of the careless worker, but merely means that possible carelessness must be regarded as one of the hazards which management must guard against just as it guards against dangerous machinery.

Management Must Be the Optimum

Lewis De Blois, consulting engineer, New York City, said that success of any undertaking depends on its acceptance by management. This applies as well to undertakings which have to do with the molding of attitudes, habits, techniques, and eventual accomplishments of the working force, as well as to the physical equipment of the plant, its arrangement, operation, maintenance, and ultimate productivity. The optimum of personnel and the optimum of plant will not combine to produce commensurate results unless management wills it and acts accordingly. Nor will the optimum product be forthcoming unless management is the optimum.

Although freedom from accidents may be, and should be, an important objective, it is not the purpose for which industry functions. Industry exists for the purpose of producing. Accidents are conditions of the productive state. Any decrease or increase in accidents affects the production of an industrial establishment. Changes of an engineering nature are capable of producing profound reductions of accidents. Such changes can be effected by management, and it can also select and instruct new employees, and maintain supervision, discipline, and provide stimulation to bring about safe use of equipment and produce safe men. Industrial-accident prevention would have progressed much further if management had not failed to interpret properly its own accident experience, and to realize the true magnitude of accident hazards. This is not due to wilful neglect, but is rather the result of short-sightedness.

Safety's Starting Point Should Be Management

That the safety problem is mainly one of education, and that it should be the duty of management to carry on this work, was brought out by A. Mac D. Hughes, personnel manager, Johns-Manville Company. Engineering and enforcement, long recognized as two important factors, amount to naught without proper education. The big task, therefore, is to point out to employees why they should, and how they can, avoid accidents. Executives are responsible for waste of materials, the condition of the machinery, and the extravagant use of money, and should be responsible for the physical condition of their man power.

Mr. Hughes gave some figures of compensation costs for his company. These showed a compensation cost for the first 10 months of 1930 of $8400 as compared with $24,000 for the same period of 1929. He emphasized the fact that safety must start from within, and that the starting point should be management.

No Casualty Without a Hazard

"If hazards are eliminated there will be no casualties from them," said H. W. Mowery, safety engineer, American Abrasive Metals Company, presiding officer and chairman of the A.S.M.E. Safety Committee. "While the education of workmen to be careful is desirable," he continued, "it is important only in reducing the casualties that are due to personal carelessness." These cost a smaller proportion of the lost time and compensation paid than do the fatalities and severe injuries preventable by engineering revision.

Workers come and go; they may be educated by lectures, bulletins, etc., on safe practices, but as long as the hazards remain, casualties result. Engineering revision permanently prevents casualties by removing the hazards. Chairman Mowery showed the efficiency of engineering revision by giving some statistics from industries in New York State. While safety education of workmen was very active and continuous during the period from 1923 to 1929, the number of compensated accidents from all causes increased 72.9 per cent. Personal causes of casualty increased from 37 per cent of the total for all causes in 1923 to 40.1 per cent in 1929, whereas the casualties due to mechanical apparatus during the same period decreased from 25 per cent to 15 per cent of the total because of effective mechanical safeguarding.

Survey of Engineering Progress

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

The "R-101" Report

WHATEVER the predisposing circumstances may have been, the immediate cause of the disaster was leakage culminating in a substantial loss of gas from one or more of the bags in the fore part of the ship." In these words Sir John Simon and his two assessors summarize their conclusions concerning the factors which led to the calamitous loss of the airship *R-101* at Beauvais in the early hours of Sunday, Oct. 5, 1930. One after another, the Court examined and rejected a series of possible explanations. Structural weakness, failure of the control gear, abnormal weather conditions, error in navigation, explosion or fire in the air, simple grounding because of lack of sufficient space in which to maneuver—these and several other possible causes were investigated and were negatived by direct evidence. It was not, however, purely as a result of a process of elimination that the Court came to the conclusion which we have set out above. That conclusion is supported by the mathematical investigations conducted by Professor Bairstow, by the opinions expressed by practical airship pilots, such as Dr. Eckener and Squadron Leader Booth, and by the experimental studies which, following the public inquiry, were made at the National Physical Laboratory. There is no evidence that the vessel was overloaded at the start of her ill-fated voyage. Her load was, in fact, just about the same as it was on October 1, when she began her 17-hr. test flight over England. Moreover, the fact that when crossing the English coast three hours after leaving Cardington the airship reported that she was recovering ballast by catching the rain that was falling on her, is held by the Court to indicate that at that time those on board her did not consider that she was too heavy. The facts are against the suggestion that the addition of an extra 45-ft. bay in the middle of her length weakened her or affected her airworthiness adversely. Studies made subsequent to the disaster showed that the lengthening of the ship had in some respects actually reduced the stresses imposed upon her. No cause other than a loss of gas from the forward bags will, it seems, fit the facts disclosed in the evidence, and that there was a substantial loss of gas is the unanimous and emphatic opinion of all three members of the Court of Inquiry.

Precisely what caused the loss of gas is a point on which the Court expresses itself with some reservation. At first sight it might appear that the loss could only have arisen by some sudden catastrophe. At 2 a.m., according to the evidence of the survivors, everything appeared to be quite normal, so much so that the watch was changed at that hour in the ordinary way of routine. Yet ten minutes later the vessel was plunging to destruction. Could such a sequence of events accompany anything else than the incidence of some cause of disaster which a few minutes earlier did not exist? The answer, in the light of Professor Bairstow's evidence, is not what might be expected. It was found on investigation that a slow, steady loss of gas would for a time require not more than a very slight adjustment of the elevators to counteract it until a certain critical condition was reached when an exceedingly rapid change in the pitching moment would occur. Chafing of the gas bags had been discovered after previous voyages, and steps had been taken to prevent its recurrence. The weather on the night of the last flight was, however, severe enough, without being abnormal, to make it highly probable, all things considered, that chafing existed to a sufficient extent to puncture the bags. The only consideration militating against the supposition that the disaster was caused by a prolonged steady loss of gas is the probability, almost the certainty, that such a loss would have been known to the officers in the control car and that in the circumstances the watch going off duty would have been told to stand by. The Court evidently feels the insufficiency of that consideration as a reason for rejecting the theory of prolonged loss with complete assurance. It is clear, however, that it is drawn toward the view, expressed by Dr. Eckener, that superimposed on the gradual leakage there was a sudden rent in one of the forward gas bags. Dr. Eckener's theory as to the series of events which led to the disaster is characterized by its fullness of detail. He pictures the vessel nose heavy by leakage at the moment when the new coxswain, unfamiliar with the "feel" of the ship, took over the watch. A gust of wind downward on the nose would accentuate the nose heaviness, but the coxswain, not quite clear about the condition of the ship, would not immediately and correctly counteract it. The ship would go into a steep dive, and the gas escaping from the damaged bag forward would travel between the bags and the outer cover toward the tail, thereby still further increasing the steepness of the dive. The violent motion of the ship produced by this combination of causes would result in a rent appearing in the already damaged bag, and, in spite of the jettisoning of ballast, it would be impossible to bring the vessel back to the horizontal. Squadron Leader Booth independently came to much the same conclusions as those advanced by Dr. Eckener. Both Captain Meager and Squadron Leader Wann—captain of the ill-fated *R-38* at the time of her disaster—differed only as to the allocation of the instant at which the rent occurred in the forward gas bag. It is significant that for the third alternative, namely, that the loss of gas was caused solely by a sudden failure of one of the bags, no support was forthcoming in the evidence laid by the Court. The loss was caused either by slow leakage or by a sudden rent superimposed on a slow leakage and attributable to the weakened condition of the leaking bag.

The Court's task was limited to ascertaining, as far as was possible, the course and cause of the disaster. It is for others, it says, to determine whether the experiment of airship travel should be further pursued. If our voice can help those others in their difficult and responsible duty of coming to a decision—as come to a decision they must now that the report has been published—then let it be heard. Neither sentiment nor national pride should be allowed to influence that decision. The question must be determined solely in the cold light of science. When the *R-38* broke her back over Hull, aeronautical science was taught a sharp, painful, but valuable lesson. When the *Shenandoah* was wrecked in America, an equally valuable addition was made to man's knowledge of the air, and the forces which it can exert. In the circumstances of the disaster to the *R-101*, as revealed by

the Simon report, we fail to find any fact which can be claimed to extend our knowledge of what to do and what to avoid in building airships. It may be argued that had the airship been filled with helium instead of hydrogen, few, if any, of those on her would have lost their lives, for it was the fire and not the crash which was chiefly responsible for the deaths of those who perished. But the crash would have occurred, whether helium or hydrogen had been used. It was neither the nature of the gas, the form of the ship's structure, nor the character of her engines which led to the disaster. Its primary cause resided in the simple fact that all airships are and must be dependent for their freedom from disaster upon the maintenance of an escapable gas within a defined space. In that sense, the disaster is far more fundamental in its nature than any which have preceded it. The accidents to the *R-38* and the *Shenandoah* could be, and rightly were, regarded as incidents in the development of the airship. We shall be surprised and grieved if in the disaster to the *R-101* science seeks to find an excuse for renewed efforts to construct a successful airship. "That event brought to a close, in a few moments of tragedy, an enterprise upon which years of concentrated effort had been directed by the pioneers who perished." Let the words with which Sir John Simon and his colleagues close their report be an epitaph, not only to the men of the *R-101* but to the large passenger-carrying airship generally. (*The Engineer*, vol. 151, no. 3925, Apr. 3, 1931, pp. 377–378, *g*)

The Hiraki-Bane Variable-Section Aerofoil

FROM the results of model experiments in a wind tunnel it is claimed that the speed range of an originally non-variable-wing airplane can be increased from 25 to 30 per cent by refitting it with this variable wing.

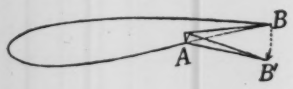


FIG. 1 THE HIRAKI-BANE VARIABLE-SECTION AEROFOIL WITH HINGE

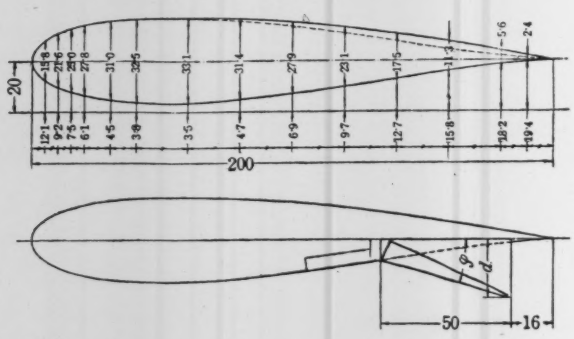


FIG. 2 THE HIRAKI-BANE AEROFOIL, ORIGINAL SECTION

In the Hiraki-Bane Aerofoil the trailing portion is split into two parts, upper and lower, along its chord. The upper part is merely an extension of the main leading portion, while the lower part is connected to the main portion as a hinged flap with the hinge at the point *A* in Fig. 1.

When the hinged flap is closed it behaves just like the original aerofoil and its aerodynamical characteristic is quite the same as that of the original one. But when the flap is opened, its lift coefficient becomes greater than that of the original aerofoil, and the excess of the lift coefficient increases in proportion to the increase of the opening.

The maximum lift coefficient of the Hiraki-Bane reaches 17.5 when the opening angle of the flap (Fig. 2) φ = 26 deg. 1 min., while the maximum lift coefficient of the non-variable aerofoil is 1.17. It is claimed that in the Hiraki-Bane wing the angle of incidence corresponding to the maximum lift coefficient does not change by varying the angle φ. It is further claimed that the new wing permits an increase in speed, but this is based on a calculation only. The results of the wind-tunnel measurements of the model shown in Fig. 2 are given in Fig. 3, where φ indicates

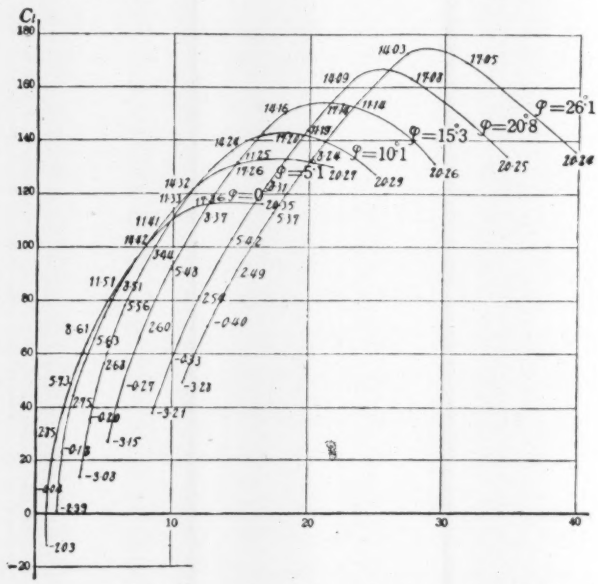


FIG. 3 DATA OF WIND-TUNNEL MEASUREMENTS OF THE HIRAKI-BANE AEROFOIL

the opening angle of the flap. (Tetsuwo Noda in a paper before the Society of Mechanical Engineers of Japan, published in full in the Home Edition, vol. 33, no. 155, pp. 131–137; abstracted from abridged publication in the Foreign Edition of the *Journal of the Society of Mechanical Engineers*, vol. 33, no. 3, Sept., 1930, pp. 151–154, 3 figs., *de*)

ENGINEERING MATERIALS (See Metallurgy: Cupola-Melted Material With a 1 Per Cent Carbon Content)

FUELS AND FIRING

Mechanism of Combustion of Individual Particles of Solid Fuels

THE present paper gives the results of an investigation of the effect of particle size, air velocity, temperature, and humidity on the rate of burning of carbon particles under carefully controlled conditions. The method involves bringing accurately shaped and weighed spheres of carbon to a known temperature in an inert gas, suddenly blasting the particle with an air stream of known velocity and temperature for a very short interval, quickly quenching the particle in inert gas, and again weighing to determine the amount of reaction. Careful records of particle surface tension during the combustion have been obtained. Only the conclusions of this interesting paper can be reported here: namely,

(1) The specific surface-reaction rate for carbon spheres burned in dry and moist air is a complex function of the particle size. It is enormously larger for a small particle than for a large one.

(2) The temperature of the surface increases as the particle is reduced in size.

(3) At the lower velocities, below about 4 ft. (122 cm.) per second as measured at 24 deg. cent., the reaction rate increases rapidly with increase in velocity, independent of other variables. This increases continually as the velocity increases, until in the high-velocity range a large increase in velocity increases the reaction rate only slightly.

(4) Size of particle, independent of other variables, has an effect on specific surface-reaction rate; that is, for the same air velocity and the same surface temperature, a small particle has a higher specific surface-reaction rate than does a larger one.

(5) Carbon spheres of surface area 70 to 10 sq. mm. burn faster in dry air than in moist air.

(6) The surface temperature is higher when the particles are burned in moist air.

(7) An increase in surface temperature, for particles burned in dry air, increases the reaction rate—that is, the temperature coefficient is positive. The maximum temperature coefficient is associated with small particle size, high air velocity, and high surface temperature.

(8) An increase in surface temperature for particles burned in wet air at low velocities decreases the reaction rate, but for higher velocities the reaction rate increases with rise in surface temperature.

(9) A mechanism explaining the observed effects of water vapor on the combustion of electrode-carbon spheres burned in wet air is suggested. (David F. Smith and Austin Gudmundsen, Pittsburgh Experiment Station, U. S. Bureau of Mines, Pittsburgh, Pa., in a paper presented before the Division of Gas and Fuel Chemistry, American Chemical Society, Cincinnati, Ohio, meeting, Sept. 8–12, 1930; abstracted through *Industrial and Engineering Chemistry*, vol. 23, no. 3, March, 1931, pp. 277–285, 14 figs., short bibliography, *eA*)

Low-Temperature Coal-Distillation Plant at Dunstan, England

THIS plant was installed some years ago by Babcock & Wilcox, Ltd., and consists of two retorts each with a throughput of 30 tons per day. Four years' experience has shown that the fuel and operating costs of these plants amount to 16s. 8d. ($4.06) per ton of coal treated, while the total value of the semi-coke and other by-products is 19s. 7.6d ($4.76). In spite of these satisfactory results it became evident that economically it would be more satisfactory to employ larger retorts, because this would enable the labor costs to be reduced. A larger unit was designed on somewhat different lines (the original installation of which was described in *Engineering*, vol. 126, 1928, p. 787), and capable of distilling 60 tons of coal per day. The most important modification of this new plant, compared with the old, is that the hot semi-coke, instead of being delivered to the stokers or pulverizers direct, is first quenched, thus enabling about 50 per cent of the steam required in the distillation process to be obtained very cheaply. This quenching also permits the retorts to be run independently of the boiler plant, so that continuity of operation and high-load-factor working, two important points in the success of such a process, are possible. Further, it eliminates any risk of burning-back taking place in the stoker hoppers. The actual process of distillation is, however, the same as before, that is, a comparatively shallow bed of fuel is exposed to a mixture of hot inert gases and steam, as this is, it is claimed, more economical than the employment of superheated steam alone. It also enables the temperature to be controlled within narrow limits and facilitates the construction of large units of simple design. Finally, it insures that the temperature, both of the charge and of the retort, does not exceed that of the distilling medium, so that the risks of uneven carbonization and of the tar oils cracking are eliminated.

As regards the actual distillation process, this is extensively illustrated in the original article. The coal is first passed through a chute and coal meter into a preheater which is of the same width as the retort and is simply a standard chain-grate stoker enclosed in a brick chamber. It moves the coal forward at a speed of about 50 ft. per hr. During this passage through the preheater the coal is heated by waste flue gases admitted at a temperature of about 200 deg. cent. The preheating process occupies about 15 min., and its objects are to prevent the condensation of oil vapors in the retort and to reduce the amount of heat required for distillation. Tests have shown that by the use of preheating in this way the moisture content can be brought down from 9.8 per cent to 2.6 per cent and the temperature raised to 130 deg. cent. In future installations the preheater will be placed directly above the retort in order to save space. From the preheater the dried coal is discharged through a rotary valve which revolves at a speed of 6 r.p.m. and prevents any escape of gas into the mouth of the retort. The latter has a rectangular steel framing substituted for the circular retort, as it was found that this was the only way in which a large output could be secured economically.

The fuel bed in the retort is supported on six rollers, which also act as coke extractors and divide the retort proper from the hoppers into which the distilling gases are admitted. These gases are obtained from a combustion chamber which consists of a brick furnace. It is fired by a burner which, as already mentioned, is supplied with coke-oven gas. The products of the combustion of this gas are mixed with steam, some 0.3 lb. of which is required per pound of coal distilled, and about half this quantity is obtained by quenching the coke. The products of combustion and steam are then passed into a brick-lined pipe, or attemperating chamber, where they are thoroughly mixed, their temperature being closely controlled by varying the proportions of the steam employed, while the composition is continuously sampled by an analyzer of the Akron type, with a view to maintaining the correct percentage of oxygen in the gases entering the retort. The mixture is next admitted to the hoppers through branches in which dampers are fitted so that the heat distribution in the two sections of the retort can be adjusted and uniform heating throughout the fuel bed obtained, the object being to insure that the temperature of the leaving gas is between 300 deg. cent. and 350 deg. cent.

One of the extractor rollers on which the fuel bed rests, as well as the way in which it is built up, is shown in an illustration in the original article. The roller consists of a 7-in. square mild-steel shaft, which is provided with a central hole so that it can be supplied with water for cooling purposes. On this shaft are threaded twenty-nine star wheels. These wheels, which are not machined, and are only a loose fit on the shaft, are arranged helically by assembling the first wheel and then placing the others progressively on the shaft in such a way that corresponding teeth are staggered at an angle of 90 deg., the final effect being to form a helical series. The teeth on these wheels are made of non-growing cast iron, collars being provided so that small openings are left between them through which the gases can pass upward into the fuel bed. The rollers revolve at a maximum speed of $1^1/_4$ revolutions per hour, the actual speed being determined by the depth of the fuel bed in the following way.

As already mentioned, the fuel is spread by a scraper conveyor. This is fitted with a feeler plate which is carried on a shaft extending across the retort. This plate is lifted up by each scraper bar as it passes, and then drops on to the surface of the coal, thus indicating the level of the fuel bed. As shown in illustrations in the original article (Figs. 15 and 16), this plate is balanced by a counterweight, and is in turn connected to a balanced vertical rod.

The upper end of this rod is provided with a rack, with which a pinion engages. This pinion is connected to the arm of a rheostat (Fig. 17 of original article), thus enabling the speed of the 1¼-hp. motor which drives the hydraulic gear operating the extractor rollers to be varied between 500 and 1000 r.p.m. This gear (also shown in Fig. 17) consists of a camshaft which opens and closes four control valves, all of which are contained in one body, the length of the interval during which the operation is repeated depending, of course, on the speed of the motor. The first cam controls the first control valve *A*, which is connected to one side of the hydraulic rams operating the extractor rollers Nos. 1, 3, and 5, so that when it is opened a pressure of 250 lb. per sq. in. is applied to the left-hand face of the piston and the roller is moved round. The second cam, which comes into action next, opens the exhaust valve *B*, so that the piston is freed from pressure, while the third and fourth cams *C* and *D* operate the rams connected to the extractor rollers Nos. 2, 4, and 6 in a similar way. The general arrangement of these cams and valves and the construction of the ram are shown in illustrations in the original article, from which it will be seen that the direction of rotation of the rollers can be reversed by throwing over a pawl, thus enabling coke to be extracted alternately from each part of the retort served. It may be added that an essential difference between the arrangements in this and the former report is that the coke now builds up a seal between the extractor rollers, so that the size of the product extracted is controlled by the spacing between the teeth. This has enabled the steam-cooled A-frames, formerly used, to be replaced by brick arches, with the results that a better heat economy is obtained and there is no longer any risk of the frames sagging.

After treatment in the manner just described, the solid fuel, which is now semi-coke, is discharged by the extractors into the retort hoppers and passes thence through a rotary valve on to the quenching conveyor.

Though the method of dealing with the coke just described is that normally in use, investigations are now being carried out with a view to discovering whether it is possible to grade this product, so that the portion which may be suitable for domestic purposes is separated from the rest before quenching takes place, as it has been found that the amount of water used for quenching must be adjusted, to each particular grade, so that the moisture content of the final product shall be correct. (First instalment of a serial article. *Engineering*, vol. 131, no. 3401, March 20, 1931, pp. 386–389, and plate 21, 21 figs., *d*)

HYDRAULICS

Water Raising From Underground Sources

THIS paper is devoted to the subject of pumping from bore holes and confines its attention almost entirely to the centrifugal or turbine type of pump as applied to this kind of work. As the pump itself must always be practically at water level, the various methods of raising the water appear to fall into two main categories, namely, (1) the pumping plant and its means of driving are both placed below ground level, and (2) the pumping plant is placed below the ground level with the means of driving at the surface. In the former the electric motor is invariably the means of driving, and it is in this field that the centrifugal or turbine pump, especially of the multi-stage type, is now so much employed because of its suitability for direct coupling to a high-speed electric motor, its low capital and maintenance cost, and the small space required for a pumping plant for a given duty.

The authors consider that there are greater possibilities of change and improvement in the second category. For many years reciprocating pumps of various types and air-lift plants have been used for this class of work, but during recent years the centrifugal and turbine pump have been largely developed for this purpose. In general, from the point of view both of capital cost and efficiency, the plants themselves are in the order of reciprocating, centrifugal, and air lift. But from the point of view of quantity of water which can be obtained from a bore hole of a given diameter, the order is reversed. After discussing in general the various types, the authors proceed to the specifications of the pumps that can be used and some of the details of construction. The article is not generally suitable for abstracting. The main features of the problem from the point of view of centrifugal pumps, in general used in the second category, are set out as follows: (1) The pump itself has to be separated from, yet attached to and suspended from the means of driving. (2) The outside diameter of the pump has to be relatively small. (3) At least two connections have to be made between the pump and the surface gear, namely, the pipe serving as a rising main and the shaft for power transmission. On occasions there may be a third, in the form of a shaft tunnel. (4) The rising main has to carry not only its own weight and the weight of the stationary parts of the pump, but also the load due to the weight of the water. The shaft has, in addition to transmitting the driving power, to carry the weight of the rotating parts, and often also a hydraulic load. (5) The shaft has to be supported at intervals in bearings, which can only, in general, be water lubricated. (6) As the pump can only be installed by being lowered into position

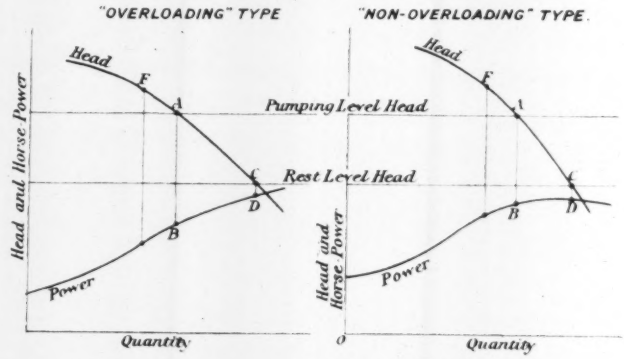


FIG. 4 HEAD AND HORSEPOWER CHARACTERISTIC CURVES FOR OVERLOADING AND NON-OVERLOADING TYPES OF BORE-HOLE PUMP

in the bore hole, it is essential that it should be built into suitable lengths for erection purposes. (7) As, sooner or later, a pump must be withdrawn from its bore hole, it is obviously essential that all parts should easily come apart. (8) Owing to the weight of the rotating parts, considerable axial loads have to be dealt with by means of suitable thrust bearings. (9) The water being pumped often contains sand and grit in suspension, making some form of protection for the bearings an essential feature.

As to strainers, the tendency today appears to be to fit fine-mesh strainers, which involves a danger of the strainer's being choked or collapsing or the bore hole's being silted up if the strainer restricts too much the passage of the sand. Foot valves are not considered altogether desirable, and the author gives curves for loss of head across the foot valve.

In the pumps themselves the restrictions imposed by the limiting outside diameter introduce certain mechanical difficulties and complications.

A considerable amount of the available diameter is required for the formation of the eye of the impeller, through which the whole of the water has to pass before energy can be transmitted to it by means of the impeller blades. Quite an appreciable amount is also required to provide adequate means for converting

the high velocity of the water leaving the periphery of the impeller into pressure. The net result is that, in all cases, the impellers have to be of the short-blade type, that is, of small outside diameter as compared with the eye diameter. The head per stage or per impeller is therefore inevitably small, in many instances being little more than 20 ft.

Where there is a considerable difference between the rest level and the pumping level of the water, it is at times desirable, particularly in the case of alternating-current rotor drives, to consider impellers of the "non-overloading" or "self-regulating" type, as distinct from the ordinary or overloading type, with a view to preventing the demand for power exceeding the safe limit of the motor. Fig. 4 illustrates this point by a comparison of the two types.

In each case the head and horsepower characteristic curves are plotted on a quantity basis, and the quantity and power at rest level are given by the points *C* and *D*, respectively, and at the pumping level by the points *A* and *B*. It will be noted that the difference between the power points *B* and *D* is appreciably less in the case of the "non-overloading" type than in the other. The question might naturally be asked, why should not the impellers always be of the "non-overloading" type? Apart from the somewhat debatable point whether the efficiency of this type is of necessity lower than that of the other, it is certain that a lower head per stage is obtainable, and consequently there is an increase in the total number of stages required and in the cost.

It should be pointed out that the "self-regulating" type has also a distinct advantage if a pump has for any reason to be operated at a reduced quantity by means of throttling. This will be seen from Fig. 4, for if the quantity has to be reduced from that represented by the point *A* to that at *F* the reduction in power is appreciably greater in the ordinary than in the "non-overloading" type. Mechanically, the main difficulty is to secure water passages of low resistance, especially from one impeller to the next, as friction and eddy losses mean much when the total head developed per stage is so small.

The bearing at the tail end of the pump shaft presents difficulties only when the water contains grit.

The mechanical balancing of the rotating parts is a question about which there has been much discussion, especially whether they should be balanced dynamically as a whole. Since each of the rotating parts is short in an axial direction, the whole of the parts may therefore be taken as being made up of a number of comparatively thin disks. If each of these parts is separately balanced statically, then the whole should be in balance both statically and dynamically. If, on the other hand, dynamical balancing of the whole were relied upon, it is quite possible to have the impellers, for example, out of balance in themselves, and, in the event of an impeller being replaced by a spare impeller, a state of unbalance might arise, necessitating a rebalancing of the complete whole. The authors are therefore of the opinion that each rotating part should be individually balanced. The case is very different from, say, the rotor of an electrical machine, which has to be treated as a whole and always remains the same whole.

As regards shafts, the authors consider the general design, and particularly the subject of critical speed or speeds. The critical speeds depend so largely upon the end conditions, i.e., upon the methods of carrying and steadying the shaft, that unless these end conditions can be postulated with a considerable degree of certainty, calculations appear to be of little use, as the authors illustrate by actual figures. They also call attention to the following two points: First, pump shafts are running in water, and although this appears to have a damping effect on the vibrations, it is important to note that it does not materially alter the frequency, for Stodola records experiments carried out on a small shaft which had critical speeds in air of 300, 820, and 1700 r.p.m., and these became 310, 850, and 1700 r.p.m. when the shaft was surrounded by water. Second, it is at times advocated, presumably with a view to avoiding critical speeds, that the bearings should be unevenly spaced, but this arrangement increases the number of possible critical speeds, and certainly the difficulty of calculating them. It appears to the authors to be better to endeavor to establish conditions which make the critical speeds amenable to calculation, for if they are known they may always be avoided; whereas to find, on starting up a plant, that they synchronize with the running speed of a pump already in a bore hole is costly, to say the least of it.

While it is usual to run shafts at speeds below the critical speed, there are occasions when conditions make this practically, or at least commercially, impossible. In these cases the normal running speed should be well above the critical, and provided the plant is accelerated fairly and rapidly, no ill appears to result in practice from thus running through the critical speed. It is not usual to be troubled with the critical speeds of the pump shafts themselves, as these are generally comparatively short and are stiffened by the impeller bosses and sleeves.

Specifications are given for the design of shaft couplings, and five types of them are illustrated. The matter is of importance, and there seems to be considerable room in the design of these couplings, especially from the manufacturing point of view.

As regards bearings, reference is made to *lignum vitae* and rubber-lined bushings. In an actual case of a pump dealing with hot water, rubber-lined bearings were entirely unsatisfactory, as there was a very marked decrease in diameter of the bore of the bearings with rise in temperature, and in addition a process of growth appeared to take place which quickly caused the running clearance to disappear.

The spacing of the bearings is a matter which requires some consideration, for although they act only as steadying agents, the distance between them governs, as previously pointed out, the speed at which a given shaft can be run with freedom from vibration troubles. The shaft lengths, too, must be spaced to agree with the lengths of the rising main, and must not be so long that difficulties arise in erection. Spans of from 7 ft. to 10 ft. are common for the shaft bearings.

It is insufficient to consider only the lubrication of the shaft bearings when the pump is running. The starting conditions may be the more onerous, for those bearings which are above the rest level of the water in the bore hole are liable to become dry if the plant has been standing for some time, and it may be quite an appreciable time after starting before water can reach them. Under bore-hole conditions fortunately, *lignum vitae* appears to retain its moisture for a considerable time. Even after days of standing, if withdrawn from a bore hole very little drying is evident, and they are good for any ordinary starting process. Rubber bearings, however, seem to be at some disadvantage in this respect.

In the discussion which followed Wm. Reavell disagreed with the figures quoted by the authors from the paper by A. W. Purchas regarding lift and submergence. These figures deal with the increase in depth required for the satisfactory operation of an air-lift plant, and were first published in *Engineering*, vol. 104, (1917), p. 561.

W. A. Dexter thought some attempt should be made to standardize the diameter of bore holes in order to reduce the number of sizes of pumps now made. The authors' reference to the use of reciprocating pumps in cases where running costs were important seemed to him misleading. Maintenance charges were an important factor, and solid matter, such as sand, caused serious wear and loss of efficiency in a reciprocating pump. He knew of an

instance in which the maintenance charges of a reciprocating pump were so heavy that it was removed and a centrifugal pump substituted at a cost of less than the equivalent of two years' maintenance charges. The change had proved remunerative. On the other hand, he knew of a case where centrifugal pumps had passed 200 tons of sand in 6 months, and at the end of that time had been found to be practically in as good condition as when first installed. In other cases nothing had been expended on maintenance after two years' daily use, averaging 18 hr. per day.

H. R. Lupton discussed the efficiency of the centrifugal pump. After giving some figures he expressed an opinion that the importance of a high efficiency was being somewhat overlooked at the present time, too much attention being paid to first cost. If electric power was taken as obtainable at $^1/_2$ d. per unit (about 1 cent per kw-hr.) and assuming continuous running, interest on capital at 5 per cent, and a 15 years' amortization period, the difference between an efficiency of 60 per cent and one of 85 per cent represented 75 ($365) per water horsepower. In the case of a pump of 100 water horsepower, this represented £7500 due to the capitalized value of the superior efficiency of a pump having 85 per cent efficiency as compared with one having 60 per cent; in other words, between reciprocating and turbine bore-hole types of pump. The motor efficiency in each case had been taken at 90 per cent.

With an oil-engine drive the discrepancy was still greater, due to the gearing required, but, as oil fuel was considerably cheaper than electric power, with an oil engine the superior efficiency of the reciprocating as compared with the turbine bore-hole pump would, taking a general case, be about £37–10 s. per water horsepower. These figures assumed continuous running. If the running were intermittent the turbine pump might justify itself economically. The calculations he had made were based on the assumption that the water levels were normal.

F. E. F. Durham gave some data of a plant recently installed by the Metropolitan Water Board, while several other discussers spoke on the submersible type of pump. (R. S. Allen and W. E. W. Millington in a paper before the Institution of Mechanical Engineers, London, March 20, 1930; abstracted through *Engineering*, vol. 131, no. 3402, March 27, 1931; original paper pp. 435–438, and discussion pp. 430–431, 13 figs. in the original paper, *cp*)

INTERNAL-COMBUSTION ENGINEERING

The Jalbert Heavy-Oil Engine

THIS engine, said to be under construction for the French Air Service, belongs to the class using a carburetor and a premixing and compression cylinder. The engine is a six-in-line with bore of 4.92 in. and stroke of 7.09 in. and is expected to develop 180 hp. at 1930 r.p.m. In place of the fuel pump and injector of the Diesel engine the Jalbert has a carburetor which feeds a small cylinder mounted on the head of each working cylinder.

The small cylinder is fitted with a piston connected up to an overhead crankshaft by means of a connecting rod, and running at half engine speed. Connection is made between the fuel cylinder and the working cylinder by means of an automatic valve having a very small lift. On its downstroke the fuel piston uncovers a port connecting with the carburetor and thus draws a mixture into the cylinder. This mixture is compressed on the return stroke, while air is being compressed in the working cylinder. Approximately at upper dead center of the two pistons, with a timing which gives a slight lead of the fuel piston over the working piston, the automatic valve opens and the mixture passes into the working cylinder. Compression is higher in the fuel cylinder than in the working cylinder; the lift of the valve is stated to be only a few hundredths of a millimeter, and the closing is very rapid by reason of the immediate rise in pressure in the combustion chamber. All possibility of preignition in the fuel cylinder is avoided by reason of the richness of the mixture, which does not become inflammable until it is mixed with the air in the working cylinder.

The carburetor is of a simplified type comprising a jet in a venturi tube and a needle valve regulating the amount of the fuel admitted. The author of the article advises that the engine seems to be quite similar in principle to one known as the Romeiser, described in the New York *Times*, March 30, 1931. (W. F. Bradley, Paris correspondent, in *Automotive Industries*, vol. 64, no. 14, April 4, 1931, pp. 548–549, illustrated, *d*)

Waste-Heat Boilers on Diesel Engines

THIS article is written with special reference to marine engineering, and points out that there are two general services to which steam generated in an exhaust-gas boiler can be applied. One is the operation of auxiliary machinery, and the other is heating the crew's quarters and passengers' accommodations and also taking care of the galley requirements. The former has been tried but has not yet met with universal approval, and even for heating purposes waste-heat steam has limitations. For example, on some of the large passenger motorships operating on the North Atlantic the heating load sometimes exceeds the capacity of the waste-heat boilers, while on freight ships the boiler capacity is usually greater than the heating load.

The capacity of the waste-heat boiler is governed primarily by the power and type of Diesel engine to which it is connected, and secondarily by the adequacy of its own design. Thus far its greatest value seems to lie in its ability to produce an essential yet small amount of steam with practically no expenditure of labor and without burning any fuel. Its potentialities have been less fully exploited on American motorships than on vessels of foreign ownership, due, no doubt, to the relatively few motorships built in this country.

Progress in the design and construction of waste-heat boilers has consistently kept ahead of the demand for such equipment, and an outline of this development is given in the original article. Part of it is taken from previously published material, particularly Maj. W. Gregson's paper presented before the Diesel Engine Users Association in Great Britain on Dec. 12, 1930.

At the close of his paper Gregson states that a tanker powered with a four-cycle engine of 2500 b.hp. will generate 2500 lb. of steam per hr. at 120 lb. pressure, or sufficient for all auxiliary purposes plus accommodation heating. On a large motorship of 20,000 b.hp. equipped with four-cycle engines, he estimates a waste-heat-boiler steam output of 20,000 lb. per hr. at 120 lb. per sq. in.—equal to more than 1250 b.hp. at the generator, and exhaust steam sufficient for the calorifiers supplying the heating system.

Next reference is made to a statement by Julius Kuttner in his "Diesel Power Plant Handbook." The Davis (Davis Engineering Company) vertical firetube boiler is then described. This boiler has many small tubes through which the gases pass at high velocity, thus setting up turbulence calculated to cause all of the gases to contact with the surface of the tubes.

The Foster Wheeler Corporation is also manufacturing waste-heat boilers. The heating elements consist of 2-in. U-bent tubes covered with external cast-iron grilled rings, which are shrunk on. These elements are held in a steel tube plate, the return-bend ends being free to move when expansion or contraction occurs. The connection ends are first expanded into holes in the tube plates and then into the flanges forming the joints. The fins provide six times as much heat-absorbing surface per lineal foot

as would the bare tubes. On the horizontal plane there are two rows of tubes at the top and four rows lower down in the boiler. All six tubes constitute a single bank of elements. One model has twelve such banks side by side. There is only one drum and no water legs. The two top rows of tubes constitute an economizer section which heats the water under steam pressure before it enters the boiler circulation. Gases upon reaching the economizer section have already passed over the lower elements where a large portion of the heat has been extracted; thus a counter-current effect is produced so as to extract the maximum amount of heat from the low-temperature gases.

Feedwater first enters the economizer section and then passes into the boiler steam drum and flows down to the lowest heating elements. A special orifice plate is fitted in the downcomer pipe so that when steam forms it will flow through the system in only one direction and establish circulation. It is an essential feature of this boiler, developed by extensive experiment, and it is claimed that the water circulation has been entirely satisfactory and free of steam hammer.

The boiler is mounted on heavy steel members and enclosed in a cast-iron casing. The return bends of the heating tubes are covered with a sheet-steel box airtight and packed with insulation. Provision for completely insulating the entire assembly is made. It is arranged for oil firing when the engine is stopped, and equipped with soot blowers, although the engine exhaust tends to keep the heating elements clean.

It is quite apparent that no harm will come to the boiler through running it dry in the presence of exhaust gases of normal temperature, say, 800 deg. fahr. It has been found to work satisfactorily as a silencer, and no provision is made for by-passing the exhaust gases around it. Consequently the steam output is governed by the amount of water fed, which is the equivalent of flash-boiler operation and eliminates the need of maintaining a given water level. It is ordinarily built to carry pressures ranging between 50 and 75 lb.

Reference is also made to the Clarkson thimble-tube boiler. (*Marine Engineering and Shipping Age*, vol. 36, no. 4, April, 1931, pp. 183–186, and 192, illustrated, *d*)

A Variable-Clearance Compression-Ignition Engine

THIS engine has been developed at the Atlas Airplane and Engine Corporation's works and installed on several White motor trucks. The volume of the clearance space or combustion chamber is automatically controlled for the purpose of making starting easier, increasing the flexibility of the engine, and limiting maximum firing pressures. Changes in clearance volume are effected by shifting the position of a movable cylinder head which is formed like a piston with rings and can move in the same bore as that in which the working piston travels. The upper portion of the piston cylinder head is threaded to fit into a nut, while the outside of the latter carries gear teeth. The nut is free to rotate under a retaining ring that cannot move axially.

Editorial comment in the journal in which the article appeared would indicate that the engine is quite crudely built. The fact that it has been able to survive even for a short time in such surroundings is one of the things that seems significant.

The principal effect of raising compression when the speed and power output of the engine are reduced would seem to be that of offsetting, to some extent at least, the fall in the operating temperature of the motor which normally results under these conditions. Apparently the small charges of fuel corresponding to light load are injected into an atmosphere almost as favorable to their ignition as are the full-load charges. That an improvement in starting and flexibility would result may well be conceded.

What is not certain is the answer to the question whether the modern auxiliary combustion chamber with heat-storage surfaces does not bring about an equivalent result. Such a chamber is a static, essentially non-mechanical element and involves none of the complication and expense associated with a movable cylinder head and its control mechanism. The question would have to be raised as to whether the extra metal could not be more profitably used in strengthening the crankcase to withstand Diesel pressures.

Details of design of the engine are given in the original article, as well as the operative claims. (*Diesel Power*, vol. 9, no. 3, March, 1931, pp. 134–135, illustrated, and editorial on p. 119, *d*)

MACHINE PARTS

Welded Gears

THE Philadelphia Gear Works announces the development of a line of welded steel gears ranging in diameter from 15 to 168 in. The rim, of 1040 S.A.E. steel plate, is cut in the form of solid ring from a flat plate by means of a gas torch. A solid rolled steel disk forms the web of the gear, against which channel-shaped pressed-steel arms are welded on both sides. The hub is a forged-steel bar drilled to receive the shaft. Hub, web, arms, and rims are welded into the finished structure, and then normalized before machining to prevent subsequent warping.

It is claimed that the metal can be distributed in the gear to best advantage, as no consideration need be given to the restriction imposed by casting conditions. There is practically no possibility of the presence of hidden blowholes, and there are no internal casting strains. The welded gear weighs about 10 per cent less than a cast-steel gear, and being constructed of metal of presumably uniform density throughout, the gear may be said to be entirely balanced. (Abstract of a trade notice sent out by the manufacturers, *d*)

MACHINE TOOLS

A New German Automatic Lathe

THIS lathe has been developed by Ludwig Loewe & Co., Berlin, and is known as the automatic "Mulka." The machine is provided with an inclined spindle which causes the chips to fall away easily and simplifies the matter of cooling. The headstock forms a unit with the tool slides and with the cam barrel. Most of the driving elements are embodied in the headstock, while some of them are attached directly to it. The machine is intended either for automatic bar work or for semi-automatic chuck work on forgings and stampings, and may be supplied either with a turret slide having four tool stations or with an ordinary slide in which the usual center may be fitted when dealing with certain classes of work. The spindle is rigidly supported in three roller bearings.

The intensity of tool pressure likely to be encountered with a machine of this nature has of course made it necessary to pay particular attention to the design of the chucking system. A system is used in the automatic Mulka which provides for differences in the size of the bar up to 2 mm. on the diameter without interfering with the tightness of the grip, and black rolled stock as well as bright drawn bar may be employed. The jaws of the feed tube open automatically, and their construction makes springs unnecessary. A further advantage of the sloping spindle is seen in the fact that the bar is fed forward by its own weight, making a complicated and costly feeding system unnecessary.

The return motion of the slides is operated mechanically by segments controlled by cams fixed on the rim of the barrel. Rotation of the cam barrel is actuated by a worm and helical gear. Accelerated speed is provided for idle motions, and to prevent accident, safety pins are fitted which shear in the event

of overload on the cam barrel. For dealing with coolant a centrifugal pump is fitted, with a discharge of between 55 and 65 gal. per hr. Arrangements are made so that the coolant is discharged as near as possible to the tool edges. (*The Automobile Engineer*, vol. 21, no. 278, March, 1931, pp. 107–108, *d*)

MARINE ENGINEERING[9]

The Caprotti-Bauer-Wach Marine Installation

THE Caprotti valve already has been referred to in MECHANICAL ENGINEERING (vol. 50, no. 8, Aug., 1928, p. 638) in connection with its use on locomotives, and the Bauer-Wach system in connection with its employment in marine installations (vol. 49, no. 6, June, 1927, p. 686). The combination of the two, it would seem, should produce quite an efficient unit.

The first marine applications of the Caprotti system were made on two new paddle-wheel vessels built by Messrs. Odera, of Genoa, Italy, and put in service on Lake Como. The Caprotti gear can be applied to almost any form of poppet-valve engine, i.e., simple-expansion, compound, double compound, triple- or quadruple-expansion engine, horizontal, diagonal, or vertical. The gear can be fitted to an existing slide-valve link-motion engine either on all the cylinders or on the high-pressure cylinder only, preserving the ordinary link motion on the remaining intermediate-pressure and low-pressure units. The valves are of the double-beat type; being balanced, they are not affected by high pressure, and very little power is absorbed in operating them. They are particularly suitable where superheated steam is used because, as there are no rubbing faces, no lubrication is required. One valve is used for the steam admission and another for the exhaust, both valves being independent with separate ports. The valve cage and valve are made in a separate unit, easily withdrawn and replaced in the cylinder body. The valve spindles work in long guides without any packing gland, as the power is applied directly along the axis of the spindle, causing no tendency to wear the guides oval, as happens with the valve spindle operated directly by a cam. There is always a rapid opening of the inlet valve, and a rapid closing to cut-off. There is a constant lead for all degrees of cut-off, and the valves are at all times opened their full amount; in this way wire drawing of the steam is prevented, no matter what power is being developed. The power or speed of the engine is controlled entirely by varying the cut-off. The inlet valves are controlled quite independently of the exhaust valves, so that the steam admission is varied without interfering with the exhaust, therefore the compression and release points are kept constant, through variations of the cut-off

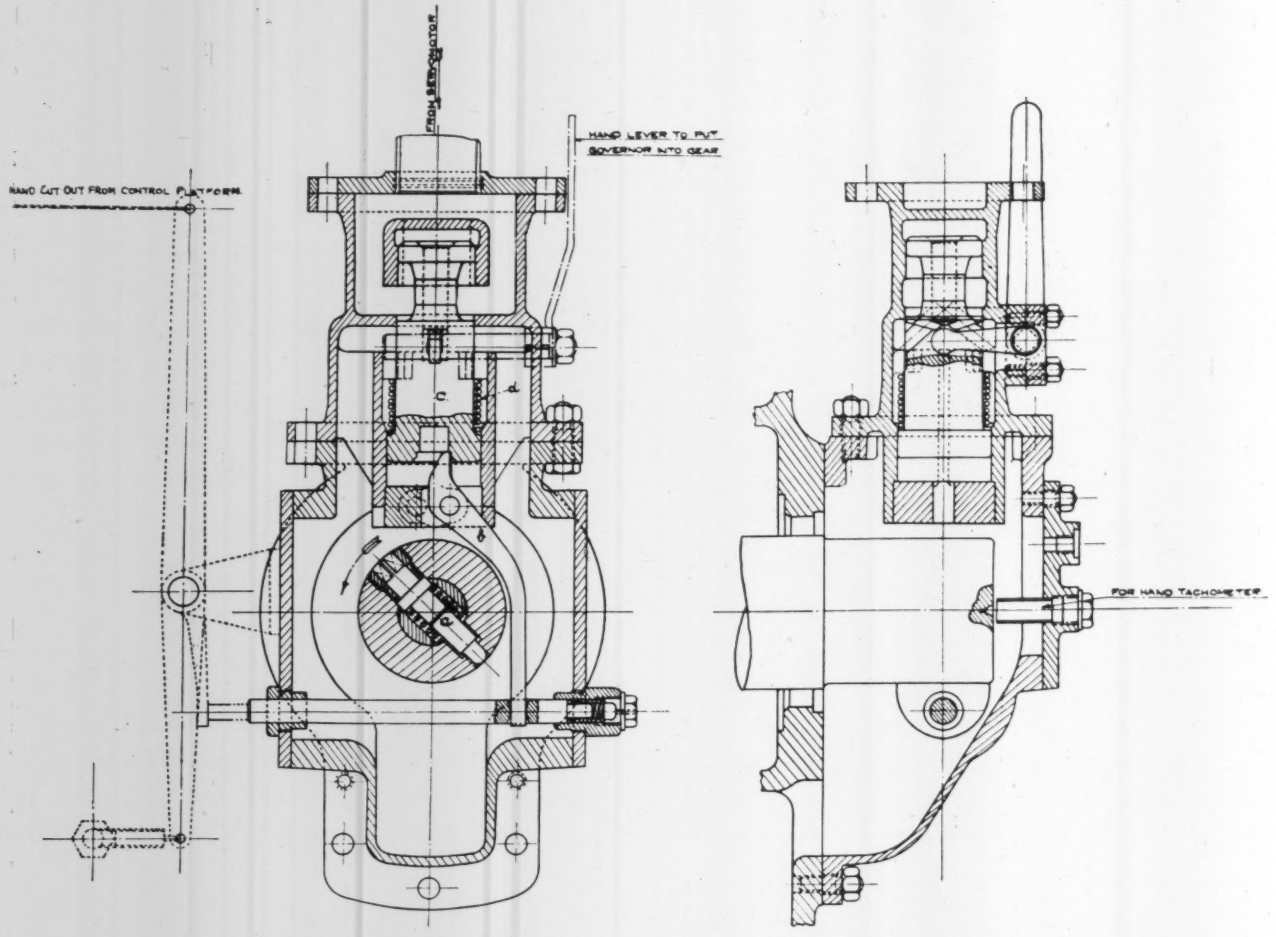


FIG. 5 SAFETY GOVERNOR ON THE CAPROTTI-BAUER-WACH MARINE INSTALLATION

The cut-off is varied by hand gear at the control platform, the throttle valve being kept full open under all conditions of load. No reversing engine is required even on large-size engines.

The paper contains references to indicator diagrams, Figs. 7 and 9, which, however, do not appear in the proof copy from which the present abstract has been made. It is said, however, that in

the diagram with the early cut-off the maximum pressure of the steam is the same as that of the later-cut-off diagram, showing the absence of wire drawing. A large number of indicator cards were taken during the progressive trials, and from these cards a curve was constructed. This curve shows the theoretical steam consumption per indicated horsepower per hour on an indicated-horsepower basis from horsepower cards. It is said that the steam consumption per indicated horsepower is reduced as the horsepower comes down, which is contrary to experience with the ordinary type of engine. This feature is of great importance, particularly in vessels where the conditions of service are of such a nature as to call for long periods of running at reduced speeds.

During the trials of one of the small vessels a "stop" order given when the ship was under way showed that the engine was more than usually inclined to rotate under the action of the water passing the propeller, and suggests that the absence of the normal valve gear had reduced the engine friction. This action created no difficulty, as the rotation was smoothly checked by moving the control toward the astern position. It may be safely assumed that anything from 60 to 100 hp. is needed to operate the normal valve gear of a reciprocating engine developing 5200 hp., but that only 4 hp., and probably less, is required to operate the Caprotti equipment on this engine.

The remainder of the paper is devoted to a description of the general installation. Steam from the low-pressure cylinder passes through water eliminators and strainers to a change valve, from which it goes to the turbine and from the turbine directly to the condenser. When the turbine is shut off the steam is bypassed through the change valve and flows directly to the condenser. The change valve consists of two flaps mounted at right angles to each other on a spindle rotated by a servo motor. In this way when the steam is going through the turbine the bypass direct to the exhaust is closed, and vice versa. The turbine is of the reaction type and has a solid forged rotor and shaft in one piece. At the forward end of the turbine is the safety governor (see Fig. 5). The bolt *a* of the governor operates at a cut-out speed of 3100 r.p.m., thereby replacing lever *b*. By this displacement piston *c* loses its support and is pressed down by spring *d*, thus releasing the oil pressure in the change-valve servo motor. The change valve is now closed to the turbine by a spring-operated closing gear, the exhaust steam being thus sent direct to the condenser. A flap valve is provided in the supply pipe to the servo motor, having a small hole in it, so that when the governor operates the pressure of the escaping oil will have fallen off sufficiently to insure that the closing gear will operate.

The safety governor can also be operated by hand if required, the lever *b* being displaced by a pull rope *e* led to the starting platform.

The labyrinth packing glands on the turbine are sealed with live steam to prevent air from being drawn in.

Up to date there are about 600 locomotives fitted with this valve gear, representing, together with marine sets, a total of 500,000 hp. in many parts of the world, the marine portion of this total being approximately 12,000.

A significant remark made at the end of the paper is quoted here verbatim:

"Owing to the position of industrial matters today, it may be that even in the marine field, as in locomotive practice, there is a growing feeling that experimental stations and government financial assistance would be an advantage in attempting to solve some of our difficulties. That such experimental work is necessary is indicated in an article on 'The Fuel Problem' recently which reads:

" '*The Need for Experiment.*—This is the position of the fuel problem at the moment. It is not final, of course, it is a problem which has yet to be solved, and only experiment, application, and invention, can hasten its solution. These are not wanting, but they are insufficient for the purpose. To Great Britain, the issues at stake are so vital that a national fuel policy is overdue. That is why Mr. Walter Runciman recently, at the Coal Trade Luncheon Club, made a vigorous plea for financial assistance of the Government to conduct experimentation on a more comprehensive and thorough scale. Mr. Runciman said, "As a national policy we had far better have spent £250,000, £350,000, or £450,000 upon experiments in the use of pulverized fuel than have spent that money on a bypass road to Kingston."' " (F. A. Pudney in paper before the Institute of Marine Engineers (London), vol. 43, no. 4; abstracted from proof copy, 21 pp., 40 figs., *d*)

METALLURGY

Cupola-Melted Material With a 1 Per Cent Carbon Content

AFTER a brief historical introduction the author describes the Corsalli method, which is said to be capable of producing in a cupola furnace a material with a carbon content of 1.5 per cent or less, suitable for casting purposes.

The Corsalli process consists in coating each piece of coke with some sort of limy cement which prevents combustion taking place until arrival at the melting zone. Combustion is then stated to be so rapid—and with rapidity one can associate efficiency—that the metal is quickly melted without much carbon pick-up. It is immediately tapped into a receiver, or maybe into ladles or shanks for casting.

It is stated that the tensile strength of the material varies around 33 tons per sq. in., while it has a transverse strength of about 60 tons per sq. in. A 1-in.-diameter cast bar which was hammered to $^5/_8$ in. and then turned on a lathe to $^3/_8$ in. showed the high tensile test of 64 tons per sq. in.; a second one showed 62 tons. It may be specially emphasized that these are pure workshop results, not laboratory ones.

The Corsalli iron leaves the furnace with a tapping temperature of more than 1500 deg. cent. and is, because of its low carbon content, naturally malleable. It is suitable even for thin-walled castings, and a short annealing of 48 hr. is sufficient to decrease the carbon content to 0.3 per cent, thus making it possible to bend the castings cold. The high-carbon core, containing 3.5 per cent carbon, which is often left in ordinary malleable castings, naturally influences the overall strength of these castings very badly. This is non-existent in Corsalli iron because of its low carbon content of about 1.5 per cent. The resultant material is not only in many cases equivalent to steel, but is much cheaper to produce because of the admittedly low cost of cupola melting. (Werner Gilles in *Foundry Trade Journal*, vol. 44, no. 857, Feb. 19, 1931, pp. 144, *dp*)

POWER-PLANT ENGINEERING (See also Internal-Combustion Engineering: Waste-Heat Boilers on Diesel Engines; and Steam Engineering: Critical Review of Steam-Consumption and Efficiency Figures of Steam Turbines)

A Vertical Water-Tube Boiler for Waste Heat

THIS invention relates to a vertical water-tube boiler for waste heat, especially that of water gas. The boiler consists of upper and lower drums, which are connected by straight water tubes. These tubes are clustered in the form of a cylindrical bundle. The heat-circulating path is controlled by vertical draft partitions *A* and *B*. The seating *C* carrying the upper drum is carried by a frame *D*, which also surrounds a cylindrical hollow

casing E for enclosing as closely as possible the water tubes. The casing is passed down to the foundation F, to which it is firmly secured, and by means of the wall G, the casing supports the lower drum. Apertures H, J are provided for the passage of the waste gases. The cylindrical casing is provided with holes L and M and constructed from heat-resisting and insulating materials. The casing is closed by a lid, in which flap valves N are provided as a safeguard for any possible explosion which may occur in the bundle of tubes, these being so-called explosion valves. The hot gases pass into the cylinder casing through the aperture H, and circulate up the first draft passage P and down the second draft passage Q, and finally upward through the third draft passage R which conducts the gases away through the outlet J. The feeding of the boiler is effected from a feed chamber formed by a dividing wall S in the upper drum. The circulation of the water takes place from the feed chamber downward through the water pipes in the draft passage R, in which the preliminary heating occurs, and from the lower drum, through the cluster of pipes in the first and second passages P and Q. The cylindrical hollow casing also encloses the superheater W disposed underneath the actual boiler. (British Patent No. 342,201, Jan. 29, 1931. Abstracted through *The Engineer*, vol. 151, no. 3922, Mar. 13, 1931, p. 307, *d*)

PUMPS

Two-Stage Propeller Pumps

IF TWO-STAGE propeller pumps are constructed, they will be applicable for a medium head, maintaining the good characteristics of single-stage propeller pumps; and accordingly we shall not only be able to extend the adequate lower limit of the specific speed for propeller pumps until theoretically about 60 per cent ($1 \div 2^{3/4}$) of the present ones is reached, but shall also be able to avoid the cavitation trouble which is so apt to occur in propeller pumps when applied to a tolerably higher head.

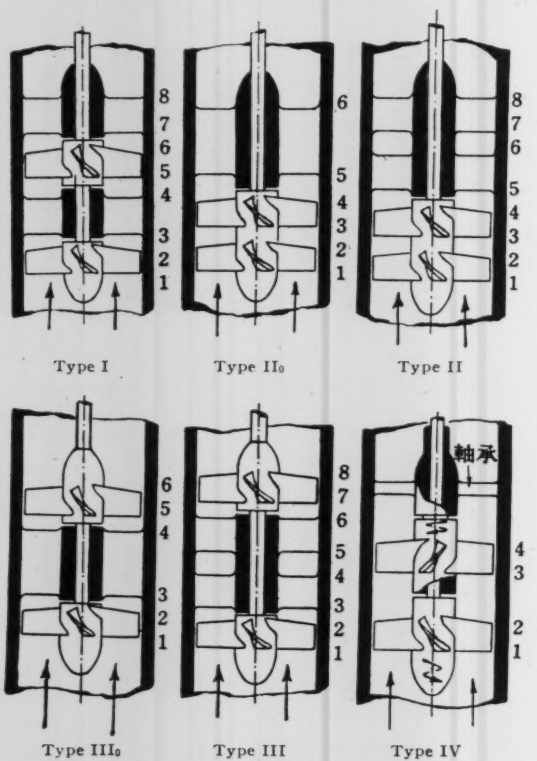


FIG. 6 VARIOUS POSSIBLE TYPES OF TWO-STAGE PROPELLER PUMPS

Since propeller turbines are now in the course of largely supplanting the well-known mixed-flow types of reaction turbine, there will be a natural tendency, the author thinks, for the two-stage propeller pumps to encroach upon the position of volute pumps of the diagonal-flow type and of other low-head types.

Several types of two-stage propeller pumps are illustrated in the original article, and the theoretical fundamental equations are derived for each type, in particular the equations for manometric efficiency. The formula used in obtaining these is slightly different from the one generally employed because the author introduces three additional factors, namely, the ratio of the outer diameter of the impeller to the inner diameter, the coefficient of the peripheral velocity of rotation, and the coefficient of the axial velocity of flow. He gives also expressions for the specific speed of the propeller pumps and then introduces this expression in the expression for the manometric efficiency of each type. This lays the foundation for a comparison of the different types, which, in turn, permits the author to compare the hydraulic efficiencies.

Among others, the author comes to the following conclusions: (1) Type I (see Fig. 6) is superior to others from the point of view of construction and manufacturing, but not in manometric efficiency. (2) Type II_0 or II is inferior to type I from the point of view of construction and complexity of design, but is superior to type I at all values of specific speeds. (3) The higher the value of k_u (coefficient of peripheral velocity of rotation) or the lower the specific speed, the greater the superiority of type II_0 or II in efficiency. (4) As regards type III, the lower the specific speed the lower the efficiency. (5) In type IV the shafts and bosses are less simple than in the other types, but it is superior to type I in efficiency when the specific speed is high, and inferior to type I when the specific speed is low. If the loss of head due to the arms of the bearing is taken into account, the efficiency will be lower than that shown in figures given in the original article. (6) In types III and IV the lower the value of k_u the higher the efficiency. (7) The tendencies of the manometric efficiencies are affected by the values of m. (Fukusaburo Numachi in a paper before a meeting of the Society of Mechanical Engineers of Japan, Apr. 18, 1930; published in full in the Home Edition, vol. 33, no. 160, pp. 471–483, abstracted from abridged publication in the Foreign Edition, *Journal of the Society of Mechanical Engineers*, vol. 33, no. 3, Sept., 1930, pp. 163–168, 15 figs., *tm*)

STEAM ENGINEERING (See also Internal-Combustion Engineering: Waste-Heat Boilers on Diesel Engines; and Marine Engineering: The Caprotti-Bauer-Wach Marine Installation)

Critical Review of Steam-Consumption and Efficiency Figures of Steam Turbines

THE article here abstracted is based primarily on the data collected by Privy Councilor Müller and published in a volume entitled, "Paper Manufacture and Its Machinery" (in German). In this work there are given, in the form of tables, data on the steam consumption of various classes and makes of turbine. The tables have been prepared in such a way that the data are comparable, and the precision of the figures is said to be of the order of 0.01 kg.

The combined efficiency of a turbine is resolved into mechanical efficiency η_m and thermodynamic efficiency η_{thd}.

The article deals exclusively with turbines of German and Swiss manufacture, and endeavors to show which make of turbine

is the most efficient. Only certain parts of general interest will be abstracted here.

On p. 197 of Müller's original work are given data of a test of a M.A.N. back-pressure turbine of 1152 effective hp. The initial pressure was 19.8 atmos. abs.; temperature, 353 deg. cent. (667 deg. fahr.); back pressure, 4.2 atmos. abs.; and speed, 6000 r.p.m. The thermodynamic efficiency as determined from temperature measurements was 84 per cent. A similar turbine was built as a counterflow turbine by the same manufacturer (table on p. 188 of book) and gave a thermodynamic efficiency of only 76.5 per cent. Even if we take into consideration the fact that in the case of an axial turbine the connection to the generator requires a drive with a mechanical efficiency of 97 per cent, it will be found that the axial back-pressure type of turbine is 10 per cent better than the Ljungström machine, and in addition is probably cheaper. The same conclusion is reached by using the data of temperature measurements on a counterflow Ljungström turbine at Leverkusen published in *Zeitschrift des Vereines deutscher Ingenieure*, Vol. 74 (1930), No. 2. In this case the measurements of steam consumption were carried out by means of a sharp-edged J. G. diaphragm orifice inserted in the live steam pipe. These measurements gave a total coupling efficiency (i.e., including gland steam) of 86 per cent. A similar test has likewise given a thermal efficiency of 86 per cent. With these figures as a start the following results of tests are obtained: Heat consumption of the turbine as per temperature measurements, 1000 kg-cal. per kw-hr.; heat consumption of the two outer stuffing boxes, 64 kg-cal. per kw-hr.; heat consumption due to leakage, 17 kg-cal. per kw-hr.; which gives a total heat consumption of 1081 kg-cal. per kw-hr. and a coupling efficiency of 860/1081 = 79.6 per cent. This figure does not consider losses through governor, oil-pump drive, etc., nor mechanical losses which, for the case of a back-pressure turbine, are given by a table (M.A.N., p. 188 of book) as 1.5 per cent. If these figures are compared with the lowest ones for an axial turbine, the latter will be found to be 6 per cent better. The reason for this is the high loss at the stuffing boxes in the case of a Ljungström turbine.

The general conclusion to which the author comes from figures not reported in the present abstract is that the axial turbine has an advantage also as a back-pressure turbine even when dealing with steam consumption at full load. At part load the axial turbine is unquestionably superior as it works by a regulation of groups of nozzles while the radial counterflow turbine works with throttling regulation.

Professor Kraft of the German General Electric Company states in this connection that throttle regulation of back-pressure turbines is justified only in exceptional cases, and in another place he says that throttle regulation of the so-called industrial turbines, particularly back-pressure and bleeder types, can be recommended only in very exceptional cases. The subject of bleeder turbines is discussed in detail. The author comes to the conclusion that for bleeder turbines the back-pressure type is best for sizes from 2000 kw. up. This part of the article is not suitable for abstracting.

In discussing axial and radial types the author has particularly in mind the Brünn and the Ljungström turbines. Both are excellent. When the Brünn turbine appeared it was generally assumed that the high-pressure parts of all turbines would from then on be built according to Brünn practice, and all the important turbine manufacturers took out licenses to employ it. The result was that the idea embodied in the Brünn turbine exerted a powerful influence on the development of steam-turbine construction, but none of the turbine manufacturers gave up their original designs. The same applies to a considerable extent to the Ljungström type. (Dr. of Engineering A. Renfordt in *Die Wärme*, vol. 54, no. 9, Feb. 28, 1931, pp. 151–155, *c*)

THERMODYNAMICS

Heat Transmission to Water Flowing in Pipes –Effect of Tube Length

EXPERIMENTS were carried out on heating water flowing at 0.62 to 22.4 ft. per sec. through a clean copper tube, of 0.592 in. inside diameter, by means of steam condensing from the the surrounding steam jacket. To determine the effect of pipe length on the film coefficient of heat flow from pipe to water, the pipe length was varied from 59 to 224 diameters, the entire length of each tube being heated. The average deviation of the heat balance was less than 7 per cent. Thermocouples were used to determine the pipe surface temperatures, and the film coefficients for the water side calculated and correlated in several different ways. When plotted, the water-side coefficients for all four pipe lengths fell in narrow bands, but not in order of the pipe lengths. For heating water in turbulent flow it is concluded that the effect of pipe length on the film coefficient of heat transmission is negligible.

A graphical analysis of the data on the overall coefficients of heat flow from steam to water, not requiring the use of the thermocouple readings, led to the same conclusion.

The film coefficients for condensing steam on the outside of the horizontal pipes were found to agree well with the Nusselt theoretical equation for this case.

In concluding that tube length has no appreciable effect on the film coefficient of heat transmission, it should be kept in mind that the present data cover only water flowing in turbulent motion and one pipe diameter. Preliminary data obtained by the authors indicate a pronounced effect of tube length for oils flowing in the viscous and lower turbulent ranges, and it seems possible that the Graetz theoretical equation may be found to hold, at least approximately, for the case of oils or other liquids having low thermal conductivities, when flowing in viscous motion.

Burbach has recently published the results of experiments on the cooling of water in a 0.197-in. i.d. tube, from which he deduces a considerable effect of tube length. Hot water was forced through a small tube surrounded with ice and the tube-wall temperature near the outlet end measured by means of an imbedded thermocouple. By repeating experiments using different tube lengths and measuring the temperature of the well-mixed water leaving the tube in each case, Burbach was able to construct curves of tube and water temperatures vs. distance from the hot-water inlet. He then calculated the film coefficients of heat flow from water to pipe at various points along the tube, obtaining the rate of heat flow at any point from the carefully measured slope of water-temperature curve. On plotting hD/k vs. $Du\rho c/k$, he found the curves for the points near the water inlet to fall considerably higher than for points farther down the pipe, and concluded that the results substantiated Nusselt's prediction of an appreciable effect on the tube length. However, when the data for a given position along the pipe, but for the various inlet-water temperatures and water velocities, are plotted as hD/k vs. $Du\rho c/k$, a wide band results, the points for the higher water temperatures falling high. The variation with water temperature is sufficient to account for the reported effect of tube length, and it seems clear that the apparent effect noted was due to the higher water temperatures near the water inlet, which were not properly allowed for in the method of correlation used. When plotted as $hD/k/(cz_m/k)^{0.5}$ vs. Dus/z_m, the effect of tube length practically disappears, except at very small values of Dus/z_m, where the spread of the curves is marked.

Furthermore, it should be pointed out that, because of heat conduction lengthwise along the tube, Burbach's assumption that the tube temperature at the center of a long tube is the same as at the end of a tube of half the length cannot be valid. It was

also found by close inspection of his data that his measured slopes of the water-temperature curves were too high for the points near the water inlet—i.e., for short tube lengths. It does not seem, therefore, that Burbach's results can be given much weight as indicating the effect of tube length on the water-side coefficient.

As indicated by the value of 180 deg. in Table VI (of the complete article), the values of h obtained by Burbach are exceptionally high. Furthermore, if Burbach's results were corrected for the appreciable temperature drop through the tube wall, they would fall still higher. Although these high values may possibly be explained by his experimental method, it seems possible that very small tubes do give abnormally high coefficients. (A. E. Lawrence and D. K. Sherwood, Worcester Polytechnic Institute, Worcester, Mass. Abstract of a thesis submitted by A. E. Lawrence for the degree of Master of Science in Chemical Engineering, Worcester Polytechnic Institute, June, 1930; abstracted through *Industrial and Engineering Chemistry*, vol. 23, no. 3, Mar. 1, 1931, pp. 301–309, 7 figs., bibliography, *e*)

WELDING

The Quality of Materials for Fusion Welding

THE ideal welded joint obviously is that one in which the properties of the weld metal and the base metal are similar both chemically and physically. Although at the present time this objective does not seem commercially attainable except in forge welding, such an ideal should be kept constantly in mind and investigation pointed in that direction. It is not within the scope of this paper to discuss the several tests of finished welds, but rather to consider the component parts uniting to produce these finished welds.

In the light of available information, the choice of materials for welding apparently does not depend so much upon the process employed as upon welding technique and the careful control of contributing factors such as temperature and pressure, in the case of plastic welding; speed and current density, in the case of electric welding; kind of flame and its proper manipulation, in the case of gas welding; flux used, etc. Therefore some of the factors discussed in the paper here abstracted apply in a general way to plastic as well as to fusion welding, and to gas as well as to arc welding.

The kind of metal (steel, wrought iron, Armco iron, Toncan iron, etc.) to be used is of course optional with the purchaser and depends to a large extent upon the product desired, but it appears that material produced by the open-hearth process is usually preferred. At the present time, grades A and B of specifications A 78-30 for steel plates of structural quality for large welding and A 89-30 for steel plates of flange quality for forge welding have found quite extensive use for all kinds of welding.

Experience has shown that success or failure in the fusion welding of steel of 0.20 to 0.30 per cent carbon and higher depends upon the use of a suitable flux applied either as a covering over the welding rod or deposited in the groove. The flux not only excludes oxygen but keeps the deposited metal in a fluid state sufficiently long to facilitate the escape of a portion of the dissolved gases.

The percentage and character of non-metallic inclusions in steel probably influence the ease of fusion welding and also the soundness of the finished weld. For this reason it is thought that open-hearth steel is better than bessemer steel, and firebox quality more adaptable than structural quality. Nevertheless it is an economic question, as with care and experience any of the commercial grades of steel can be satisfactorily welded. For very important structures such as pressure vessels and boilers the best quality obtainable will be well worth the cost.

Some steels, the chemical composition of which would indicate no difficulty in welding, give trouble. Therefore some purchasers adhere to the practice of inserting in their specifications the clause that "steel shall be of good welding quality." One consumer (American Car and Foundry Co.) suggests that one of the chief sources of trouble in welding is the presence of laminations, stating that laminations prevent proper penetration and thus cause faulty welds. Greater top discard in the ingot would largely overcome this trouble, at some increase in cost of the steel. It should be borne in mind, however, that good welding steel may be ruined by a poor quality of rod or poor workmanship.

Aside from the possible change in corrosion-resistance properties of the stainless steels, they can usually be satisfactorily welded with certain precautions by ordinary methods of welding now in use. The most frequently used 18-per cent chromium, 8-per cent nickel alloy contains less than 0.10 per cent of carbon, with a silicon maximum of usually not over 1.0 per cent.

The selection of the proper welding wire or electrode metal is shrouded in considerable mystery. There are a great number of proprietary articles on the market. In the early days of welding, the idea was prevalent that nothing but Swedish-iron welding wire could be used with any degree of satisfaction. Swedish iron is a low-carbon pure iron with about one per cent of silicate inclusions, and although its use results in very acceptable welds, special grades of steel are just as satisfactory for some purposes, and for other purposes considerably better.

A good rule to follow in the selection of welding rod or electrode is to match the quality of rod with the quality of plates being joined. It does not follow, however, that if low-tensile-strength rod is used to join higher-tensile-strength plates the weld will be relatively weak, because the weld metal derives a definite increase of strength from the plate metal which is used to unite due to carbon diffusion, and the practice of using soft welding rod is probably based on this principle.

Complete chemical or physical specifications for welding wire are practically impossible to write and may be undesirable until more data are available. This applies to the wire used in both gas welding and arc welding. At the present time the most that can safely be said is that the wire should be capable of making sound and acceptable welds.

Where corrosive conditions exist, the question arises as to whether the weld may corrode more rapidly than the base metal, or whether the one might not accelerate the corrosion of the other in the presence of an electrolyte. At the present time no material difference has been found. If the weld metal contains fissures or surface discontinuities there is the possibility of the establishment of an electrolytic cell. Furthermore, electrolytic action may result if the weld metal possesses a radically different potential from that of the base metal or if the magnetic oxide scale on the weld differs from that on the adjacent metal. In corrosive water this may result in corrosion of the base metal adjacent to the weld rather than of the weld metal itself. More data are needed on this question. Under such conditions in the case of pipe lines, the application of a suitable protective coating should be of considerable value. (C. R. Texter and F. N. Speller, National Tube Co., Pittsburgh, Pa., in a symposium on welding, *American Society for Testing Materials*, Pittsburgh Regional Meeting, Mar. 18, 1931, abstracted from preprint, pp. 25–32, *p*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Revisions and Addenda to the Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later on in the proper place in the Code.

The following proposed revisions have been approved for publication as addenda to the Code. These are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code and are submitted for criticisms and approval from any one interested therein. Communications should reach the Secretary of the Boiler Code Committee, 29 West 39th Street, New York, N. Y. not later than June 15, 1931, in order that they may be presented to the Committee for consideration.

For the convenience of the reader in studying the revisions, all added matter appears in small capitals and all deleted matter in smaller type.

PAR. P-184: REVISE SECTIONS *a* AND *b* AS FOLLOW:

P-184. *Circumferential Joints.* *a* The strength of A RIVETED circumferential joint[s] of A boiler[s], the heads of which are not stayed by tubes or through braces, shall be SUFFICIENT, CONSIDERING ALL METHODS OF FAILURE, TO RESIST THE TOTAL LONGITUDINAL FORCE ACTING ON THE JOINT WITH A FACTOR OF SAFETY OF FIVE. THE TOTAL LONGITUDINAL FORCE IS DETERMINED BY THE FOLLOWING FORMULA:

$$F = 3.14R^2P$$

WHERE F = TOTAL LONGITUDINAL FORCE IN LB.
R = RADIUS OF THE CIRCULAR AREA ACTED ON BY THE PRESSURE IN PRODUCING THE TOTAL LONGITUDINAL FORCE ON THE JOINT IN LB. PER SQ. IN.
P = PRESSURE IN LB. PER SQ. IN.

[at least 50 per cent of that required for the longitudinal joints of the same structure.]

b When 50 per cent or more of the TOTAL FORCE AS DESCRIBED IN (A) [load which would act on an unstayed solid head of the same diameter as the shell] is relieved by the effect of tubes or through stays, in consequence of the reduction of the area acted on by the pressure and the holding power of the tubes and stays, the strength of the circumferential joint [s in the shell] shall be at least 70 [35] per cent of that required BY (A) [for the longitudinal joints.]

PARS. H-40 AND H-93. MODIFY PROPOSED REVISION OF THIRD SECTION OF THIS PARAGRAPH AS PUBLISHED IN APRIL ISSUE:

It is recommended that the return pipe connection of each boiler SUPPLYING A GRAVITY RETURN HEATING SYSTEM shall be so arranged as to form a loop substantially as shown in Fig. H-3 so that the water in each boiler cannot be forced out below the safe water level.

PARS. H-55 AND H-108 REVISED:

Steam Gages. Each steam boiler shall have a steam gage connected to ITS [the] steam space or to ITS [the] water column, or its steam connection, by means of a siphon or equivalent device EXTERIOR TO THE BOILER AND of sufficient capacity to keep the gage tube filled with water and so arranged that the gage cannot be shut off from the boiler except by a cock WITH TEE OR LEVER HANDLE, placed IN THE PIPE near the gage. THE HANDLE OF THE COCK SHALL [and provided with a tee or lever handle arranged to] be parallel TO [with] the pipe in which it is located when the cock is open. [Pipe connections to steam gages smaller than 1 in. pipe size, shall be of brass, copper, or bronze composition when the distance between the gage and point of attachment of pipe is over 5 ft. If less than 5 ft., the pipe connections shall be of brass, copper, or bronze composition if smaller than 1/2 in. pipe size.]

THE SCALE ON the dial of a steam BOILER gage [for a steam heating boiler] shall be graduated to not less than 30 lb. THE GAGE [and] shall be provided with EFFECTIVE STOPS FOR THE INDICATING POINTER [a stop pin] at the zero point and [a stop pin] at THE [a] maximum PRESSURE point [not less than 300 deg., nor more than 325 deg. of the dial circumference from the zero point, unless the gage be so constructed that the pointer cannot travel over 325 deg. of the dial circumference from the zero point.] THE TRAVEL OF THE POINTER FROM ZERO TO 30 LB. PRESSURE SHALL BE AT LEAST 3 IN.

STEAM-GAGE CONNECTIONS SHALL BE OF NON-FERROUS COMPOSITION WHEN SMALLER THAN 1-IN. PIPE AND LONGER THAN 5 FT. BETWEEN THE GAGE AND POINT OF CONNECTION OF PIPE TO BOILER, AND ALSO WHEN SMALLER THAN 1/2-IN. PIPE AND SHORTER THAN 5 FT. BETWEEN THE GAGE AND POINT OF CONNECTION OF PIPE TO BOILER.

On a compound gage, AN EFFECTIVE [the] stop pins [or limit stops] shall be set at the limits of the gage readings on both the pressure and vacuum sides.

PARS. H-56 AND H-109 REVISED:

Pressure or Altitude Gages. Each hot-water boiler shall have a PRESSURE OR ALTITUDE gage connected TO IT OR TO ITS FLOW CONNECTION in such a manner that it cannot be shut off from the boiler except by a cock with tee or lever handle, placed on the pipe near the gage. The handle of the cock shall be parallel to the pipe in which it is located when the cock is open. [Pipe connections to gages smaller than 1 in. pipe size shall be made of brass, copper, or bronze composition when the distance between the gage and point of attachment of pipe is over 5 ft. If less than 5 ft., the pipe connections shall be of brass, copper, or bronze composition of smaller than 1/2 in. pipe size.]

THE SCALE ON the dial of the pressure or altitude gage shall be graduated to not less than 1 1/2 times the maximum allowable working pressure. THE GAGE [and] shall be provided with EFFECTIVE STOPS FOR THE INDICATING POINTER [with a stop pin] at the zero point and [a stop pin] at the maximum PRESSURE point [not less than 300 deg. nor more than 325 deg. of the dial circumference from the zero point unless the gage be so constructed that the pointer cannot travel over 325 deg. of the dial circumference from the zero point.]

PRESSURE- OR ALTITUDE-GAGE CONNECTIONS SHALL BE OF NON-FERROUS COMPOSITION WHEN SMALLER THAN 1-IN. PIPE SIZE AND LONGER THAN 5 FT. BETWEEN THE GAGE AND POINT OF CONNECTION OF PIPE TO BOILER, AND ALSO WHEN SMALLER THAN 1/2-IN. PIPE SIZE AND SHORTER THAN 5 FT. BETWEEN THE GAGE AND POINT OF CONNECTION OF PIPE TO BOILER.

PAR. H-120. REVISE FIRST SENTENCE TO READ:

H-120. All boilers shall be plainly and permanently marked with the manufacturer's NAME OR THE MANUFACTURER'S AND distributor's name and the maximum allowable working pressure.

PAR. U-17. MODIFY REVISION OF TABLE REFERRED TO IN APRIL ISSUE TO READ:

When the Diameter of Shell is	In.
16 in. and under	1/8*
Over 16 in. to 24 in.	3/16
Over 24 in. to 42 [36] in.	1/4
Over 42 [36] in. to 60 [54] in.	5/16
Over 60 [54] in. [to 72 in.]	3/8
[Over 72 in.	1/2]

* For riveted construction the minimum thickness shall be 5/16 in.

PAR. U-53. ADD THE FOLLOWING SENTENCE TO THE SECOND SECTION:

VESSELS 16 IN. IN DIAMETER OR LESS HAVING PIPE CONNECTIONS PROPERLY LOCATED FOR INSPECTION PURPOSES, NEED NOT BE PROVIDED WITH SEPARATE OPENINGS IF THE TAPPING FOR THE PIPE CONNECTIONS IS NOT LESS THAN $1^1/_2$ IN. PIPE SIZE.

PAR. U-20. REVISED:

U-20. *For Internal Pressure.* The maximum allowable working pressure on the shell of a pressure vessel shall be determined by the strength of the weakest course computed from the thickness of the plate, the efficiency of the longitudinal joint, the inside diameter of the course, and the maximum allowable unit working stress.

$\frac{S \times t \times E}{R}$ = maximum allowable working pressure, lb. per sq. in.

where S = maximum allowable unit working stress in lb. per sq. in.

TAKEN FROM TABLE U-$2^1/_2$

[11,000 lb. per sq. in. for steel plate stamped 55,000 lb. per sq. in., 10,000 lb. per sq. in. for steel plate stamped less than 55,000 lb. per sq. in., and for material used on seamless shells, one-fifth of the minimum of the specified range of the tensile strength of the material.]

t = minimum thickness of shell plates in weakest course, in.

E = efficiency of [riveted] longitudinal joint OR OF LIGAMENTS BETWEEN OPENINGS

FOR RIVETED JOINTS = CALCULATED RIVETED EFFICIENCY

FOR FUSION WELDED JOINTS = EFFICIENCY SPECIFIED IN PAR. U-67

FOR SEAMLESS SHELLS = 100 PER CENT

FOR LIGAMENTS BETWEEN OPENINGS, THE EFFICIENCY SHALL BE CALCULATED BY THE RULES GIVEN IN PARS. P-192 AND P-193 OF SECTION I OF THE CODE

R = inside radius of the weakest course of the shell, in., provided the thickness of the shell does not exceed 10 per cent of the radius. If the thickness is over 10 per cent of the radius, the outer radius shall be used.

NOTE: When the ALLOWABLE EFFICIENCY OF THE JOINTS IS NOT GIVEN, THE VALUES FOR $S \times E$ GIVEN [safe working pressure for welded or brazed vessels is to be determined, E will be omitted from the formula and the values for S] in Pars. U-67, [U-68], U-82, or U-94 SHALL BE USED [will be substituted for the values given above. For seamless shells, E equals 100 per cent.]

TABLE U-$2^1/_2$ VALUES FOR S AT VARIOUS TEMPERATURES

Temp., deg. fahr.	Minimum of specified range of the tensile strength of the material, lb. per sq. in. 45,000	50,000	55,000	60,000	75,000
60–730	9,000	10,000	11,000	12,000	15,000
750	8,220	9,110	10,000	11,200	13,000
800	6,550	7,330	8,000	9,000	10,200
850	5,440	6,050	6,750	7,400	8,300
900	4,330	4,830	5,500	5,600	6,000
950	3,200	3,600	4,000	4,000	4,000

This table applies to all plain carbon steels for which specifications are given in the Code. Where the minimum tensile strength of the specified range or the temperature differs from those for which values are given in the table, the values for S for such materials may be determined by interpolation.

PAR. U-66. INSERT AFTER END OF FIRST SENTENCE:

IF THE VESSEL IS OF FUSION-WELDED CONSTRUCTION IT SHALL ALSO BE STAMPED TO SHOW THE CLASS OF VESSEL AND GRADE OF WELDING.

FIG. U-5. INSERT THE FOLLOWING UNDER THE CLOVER-LEAF SYMBOL:

CLASS OF VESSEL.....

GRADE OF WELDING.....

Rules for the Fusion Process of Welding

The following paragraphs will replace the present Pars. U-67 to U-79 in the Code, and supersede the material published in the December, 1930, and March, 1931, issues of MECHANICAL ENGINEERING *under the heading "Proposed Specifications for Fusion Welding."*

U-67. Pressure vessels may be fabricated by means of fusion welding provided the construction is in accordance with the requirements for material and design as required by this Code and the fusion welding process used conforms to the specifications for the grade of welding required for each class of vessel.

Fusion-welded pressure vessels shall be classified according to the following schedule. The grade of welding required for each class shall be as indicated.

Class 1. All vessels covered by this Code, constructed in accordance with the rules for this class, may be used for any purpose. These vessels shall meet Grade A test requirements. The joint efficiency E for this class shall be taken as 90 per cent.

Class 2. All vessels covered by this Code may be included in this class, excepting those containing lethal gases or lethal liquids and/or those containing liquids operating at a temperature of 250 deg. fahr. or above (this exemption does not include vessels containing steam only). The maximum pressure at which any vessel in this class may be operated is 400 lb. per sq. in., and/or the maximum temperature 730 deg. fahr., provided the plate thickness as required by the permissible stress allowance does not exceed $1^1/_2$ in. These vessels shall meet Grade B test requirements. When Grade B test requirements are used, the joint efficiency E shall be taken as 80 per cent.

Class 3. All vessels covered by this Code, not exceeding 5/8 in. plate thickness and used for the storage of gases or liquids except water at temperatures not exceeding their boiling temperature at atmospheric pressure, and at pressures not to exceed 200 lb. per sq. in., and/or not to exceed a temperature of 250 deg. fahr. may be included in this class, excepting those containing lethal gases or liquids. These vessels shall meet Grade C test requirements. The strengths of the joints shall be calculated on a maximum unit joint working stress ($S \times E$), at right angles to the direction of the joint as follows:

Double-welded butt joints for all joints	8000 lb.
Single-welded butt joints for girth or head joints	6500 lb
Double full-fillet lap welds for girth joints only	7000 lb.
Spot or intermittent welds for girth or head joints	5600 lb.

For single-welded butt joints for longitudinal joints and for material of thickness of less than 1/4 in., the maximum unit joint working stress ($S \times E$) shall not exceed 5600 lb. per sq. in.

The allowable working stresses on the joints in pounds per square inch for different temperatures are given in Par. U-20.

NOTE: It does not follow that any vessel in which the plate thickness does not exceed $^5/_8$ in. is necessarily limited to Class 3. Any vessel welded to meet Grade A test requirements would be included in Class 1, and if welded to meet Grade B test requirements it would be included in Class 2.

The above classification gives the general features governing the classes into which the various vessels will be placed. The Boiler Code Committee will prepare a list indicating the classes into which the vessels for various uses shall be grouped.

U-68. *Material.* *a* The materials used in the fabrication of any fusion welded pressure vessel covered by this Code shall conform to Specifications S-1 for Steel Boiler Plate, or S-2 for Steel Plates of Flange Quality for Forge Welding, of Section II of the Code (1930 Edition). Shells fabricated from lap-welded butt-welded, or seamless pipe shall conform to Specification S-18 for Welded and Seamless Steel Pipe. The carbon content in all such material shall not exceed 0.35 per cent.

b Material for manhole frames, nozzles, and other pressure connections which are to be joined to the shell or heads by fusion welding shall, when forged or rolled, comply with the specifications given for shell plate and heads as to chemical and physical properties, and be of good weldable quality. Steel castings and commercial nozzles may be used only when the material has been proved to be of good weldable quality.

c If, in the development of the art of welding, other materials than those herein described become available, specifications may be submitted for consideration.

U-69. *Definitions.* *a* *Fusion Welding.* A process of welding metals in the molten, or molten and vaporous, state without the application of mechanical pressure or blows.

b *Fillet Weld.* A fusion weld of approximately triangular cross-section whose throat lies in a plane disposed approximately 45 deg. with respect to the surfaces of the parts joined.

c *Throat.* The minimum thickness of a weld along a straight line passing through the bottom of the cross-sectional space provided to contain a fusion weld.

d *Double-Welded Butt Joint.* A double-welded butt joint is one formed by the fusion of two abutting edges with a filler metal added from both sides of the joint and with reinforcement on both sides. A joint with filler metal added from only one side is considered equivalent to a double-welded butt joint when and if means are provided for accomplishing complete penetration and reinforcement on both sides of the joint.

e *Single-Welded Butt Joint.* A single-welded butt joint is one formed by the fusion of two abutting edges with all the filler metal added from one side of the joint with a reinforcement on the side from which the filler metal is added.

NOTE: For additional definitions see "Welding and Cutting Nomenclature, Definitions and Symbols," published by the American Welding Society.

U-70. *Longitudinal Joints.* Longitudinal joints on Classes 1 and 2 vessels shall be of the double-butt type and shall be reinforced at the center of the weld on each side of the plate by at least $^1/_{16}$ in. up to and including $^5/_8$ in. plate, and up to $^1/_8$ in. for heavier plates, and if not removed shall be built up uniformly from the surface of the plate to a maximum at the center of the weld. Particular attention is called, however, to the importance of the provision that there shall be no valley or groove along the edge of or in the center of the weld, but that the deposited metal must be fused smoothly and uniformly into the plate surface at the top of the joint.[1] The finish of the welded joint must be reasonably smooth and free from irregularities, grooves, or depressions. The reinforcement for a single-welded butt joint shall be not less than $^1/_{16}$ in. The reinforcement may be machined off, if so desired. The longitudinal joints of Class 3 vessels may be of the single-butt type for plate thickness of $^1/_4$ in. and less, or double-butt type for any thickness up to $^5/_8$ in., or they may be of the lap type for $^3/_8$ in. and under. If of the lap type the throat dimension of each of the welds shall not be less than $^3/_4$ T, where T represents the thickness of the plate. Both edges of the lap shall be welded and the surface overlap shall not be less than $4T$.

U-71. *Circumferential Joints.* *a* Circumferential joints on Class 1 vessels shall be of the double-welded butt type. Circumferential joints on Class 2 vessels shall be of the double-butt type except for thicknesses of $^5/_8$ in. or less, in which case they may be of the single-butt type. Circumferential joints on Class 3 vessels may be of the butt or lap type. The details of all these joints shall conform to the requirements for longitudinal joints, as given in Par. U-70.

b Dished heads concave to the pressure when used on Class 3 vessels may be inserted with a driving fit and fillet welded inside and outside, except that for vessels 20 in. in diameter or less the heads may be welded on the outside only. The welds shall be located at a distance not less than twice the thickness of the head from the point of tangency of the knuckle.

c Heads concave to the pressure and/or plate edges at girth seems to be attached by butt joints shall be aligned as truly as possible. If the deviations are more than permitted by the limitations of Par. U-74, corrections shall be made by reforming the shell or head, whichever is out of true, until the errors are within the limits specified. The edges of head and girth seams shall be kept so spaced that they shall be separated at the point of welding enough to insure thorough penetration of the weld metal.

U-72. *Dished Heads.* Dished heads convex to the pressure shall have a flange not less than $1^1/_2$ in. long and shall be inserted into the shell with a driving fit and welded as shown in Fig. U-7*B*.[2]

Dished heads concave to the pressure shall have a length of flange not less than 1 in. for shells not over 24 in. in diameter. For vessels over 24 in. in diameter this length shall be not less than $1^1/_2$ in.

U-73. *Inlet and Outlet Connections.* To be same as present Par. U-77 (1930 Edition).

U-74. *Preparation for Welding.* The plates or sheets to be joined shall be accurately cut to size and formed. In all cases the forming shall be done by pressure and not by blows, including the edges of the plates forming longitudinal joints of cylindrical vessels.

Particular care should be taken in the layout of joints in which fillet welds are to be used so as to make possible the fusion of the weld metal at the bottom of the fillet. Great care must also be exercised in the deposition of the weld metal so as to secure satisfactory penetration.

If the thickness of the flange of a head to be attached to a cylindrical shell by a butt joint exceeds the shell thickness by more than 25 per cent (maximum $^1/_4$ in.), the flange thickness shall be reduced at the abutting edges.

The edges of the plates at the seams shall not have an offset from each other at any point in excess of one-quarter of the thickness of the plate, except for plates in excess of $^3/_4$ in. in thickness, in which the offset must not be more than 10 per cent (maximum $^1/_8$ in.) for longitudinal seams, or 25 per cent (maximum $^1/_4$ in.) for girth seams.

In all cases where plates of unequal thicknesses are abutted.

[1] If the reinforcement is built up so as to form a ridge with a valley or depression at the edge of the weld next to the plate, the result is a notch which causes concentration of stress and reduces the strength of the joint.

[2] See Fig. U-7 in Code for Unfired Pressure Vessels.

the edge of the thicker plate shall be reduced in some manner so that it is approximately the same thickness as the other plate. The design of welded vessels shall be such that bending stresses are not brought directly upon the welded joint. Corner welds must be avoided unless the plates forming the corner are properly supported independently of such welds.

Bars, jacks, clamps, or other appropriate tools may be used to hold the edges to be welded in line. The edges of butt joints must be so held that they will not be allowed to lap during welding. Where fillet welds are used, the lapped plates shall fit closely and be kept together during welding.

The surfaces of the sheets or plates to be welded must be cleaned thoroughly of all scale, rust, oil, or grease for a distance of not less than 1/2 in. from the welding edge. A steel-wire scratch brush may be used for removing light rust or scale, but for heavy scale, slag, and the like a grinder, chisel, air hammer, or other suitable tool shall be used that will clean to bright metal. When it is necessary to deposit metal over a previously welded surface, any scale or slag therefrom shall be removed by a roughing tool, a chisel, an air chipping hammer, or other suitable means to prevent inclusion of impurities in the weld metal. Grease or oil on the welding edges may be removed with gasoline, lye, or the equivalent.

The dimensions and shape of the edges to be joined shall be such as to allow thorough fusion and complete penetration.

Where welding is applied from both sides of the plates to be joined, the joint on the second side must be chipped, ground, or melted out, so as to secure a clean surface of the originally deposited weld metal, prior to the application of the first bead of welding on the second side. Such chipping, grinding, or melting out shall be done in a manner that will insure proper fusion of the weld metal.

If the welding is stopped for any reason, extra care must be taken, when re-starting, to get full penetration to the bottom of the joint and thorough fusion between the weld metal and the plates and to the weld metal previously deposited.

Where single-welded butt joints are used, particular care must be taken in aligning and separating the edges to be joined so that complete penetration and fusion at the bottom of the joint will be assured.

U-75. *Stress Relieving.* All Class 1 fusion-welded vessels shall be stress relieved. Class 2 fusion-welded vessels shall be stress relieved in accordance with the following:

> All welds shall be stress relieved where both the wall thickness is greater than 0.55 in. and the shell diameter less than 20 in.
>
> For other wall thicknesses and shell diameters, stress relieving shall be required for all welds where the ratio of the diameter to the cube of the shell thickness is less than 118.

Where stress relieving is required, it shall be done by heating uniformly to at least 1100 deg. fahr., and up to 1200 deg. fahr. or higher if this can be done without distortion. The structure or parts of the structure shall be brought slowly up to the specified temperature and held at that temperature for a period of at least one hour per inch of thickness, and shall be allowed to cool slowly in a still atmosphere.

The structure shall be stress relieved by any of the following methods:

a Heating the complete vessel as a unit.

b Heating a complete section of the vessel (head or course) containing the part or parts to be stress relieved before attachment to other sections of the vessel.

c In cases where the vessel is stress relieved in sections, stress relieving the final girth joints by heating uniformly a circumferential band having a minimum width of 6 times the plate thickness on each side of the welded seam in such a manner that the entire band shall be brought up to the temperature and held for the time specified above for stress relieving.

> NOTE: A committee has been appointed to consider the question of allowing stress relief by pressure or other means.

U-76. *Hydrostatic and Hammer Tests.* *a* All fusion-welded pressure vessels shall be subjected to the hydrostatic pressure as prescribed for riveted vessels, and while subject to this pressure a thorough hammer or impact test shall be given. This impact test shall consist of striking the sheet at 6-in. intervals on both sides of the welded joint and for the full length of all welded seams. The weight of the hammer in pounds shall approximately equal the thickness of the shell in tenths of an inch, and the blow shall be struck with a force equivalent to an 8-ft. free fall of the hammer head. The edges of the hammer shall be rounded so as to prevent defacing the plates. Following this test, the pressure shall be raised to not less than twice the maximum allowable working pressure and held there for a sufficient length of time to enable an inspection to be made of all seams and connections. The maximum allowable working pressure in each case shall be that at atmospheric temperature, based on actual dimensions of the vessel and plate thicknesses as determined by the formula in Par. U-20.

> NOTE: A proposal has been made to limit the weight of the hammer to 12 lb.

Pinholes, except on longitudinal seams, may be calked, filled with a plug not to exceed 1/4 in., or welded by the metal-arc process without preheating, or they may be melted out and rewelded by any process, provided the metal around the pinhole is preheated to a dull red for a distance of at least 4 in. all around it. Any preheating means may be used, such as a flange fire, gas or oil burner, or a welding torch. The preheating should be done slowly, so the heat will get well back into the plate and expand it thoroughly. After welding, the vessel should be reheated in the vicinity of such weld until the heat has equalized in the dull-red spot, and then slowly cooled.

Pinholes in longitudinal seams must be repaired only by chipping or machining, or melting out the defect and rewelding with the above precautions in regard to preheating and reheating, except that with metallic-arc welding, preheating and reheating are not required. Cracks in welds shall only be repaired by cutting out the weld and rewelding the entire seam.

Vessels requiring stress relieving must be stress relieved after any welding repairs have been made.

After repairs have been made, the vessel shall again be tested in the regular way, and if it passes the test the inspector shall accept it. If it does not pass the test the inspector can order supplementary repairs, or, if in his judgment the vessel is not suitable for service, he may permanently reject it.

U-77. *Inspection.* The inspector may designate stages of the work at which he wishes to inspect the welded joints of a Class 1 vessel, and the manufacturer shall either submit the drum for inspection in such partly completed condition, or as an alternative he may permit the inspector to witness stages of the welding operation at such times as the inspector may select.

Class 2 pressure vessels shall be inspected at least twice, and Class 3 pressure vessels shall be inspected at least once, during construction and before the hydrostatic test.

For Class 2 vessels the first inspection shall be made during the welding of the longitudinal joint. At this time the inspector shall inspect the plate material and the fit-up of the work, and observe the workmen to see that only welders who have passed the test requirements are employed on the work of welding.

A second inspection shall be made during the welding of the circumferential joints. At this time the inspector shall check any new material being used which may not have been examined at the time of the first inspection, also the fit-up of the vessel at this stage of construction, and again observe the welding operators to see that only welders who have passed the test requirements are employed.

For Class 3 vessels one inspection shall be made during the welding of the longitudinal joint. At this time the inspector shall check the plate material and the fit-up of the work, and observe the workmen to see that only welders who have passed the test requirements are employed.

Every pressure vessel covered by this Code shall also be inspected at the time of the hydrostatic-pressure and hammer tests.

The manufacturer shall certify that the welding has been done only by welders who have passed the test requirements and that the same materials and technique used in making the tests were employed.

U-78. *Holes.* No unreinforced holes shall be located in a welded joint. When an unreinforced hole in the plate is located near a welded joint, the minimum distance between the edge of a hole and the edge of a joint shall be equal to the thickness of the plate when the plate thickness is from 1 in. to 2 in. With plates less than 1 in. thick, this minimum distance shall be 1 in. With plates over 2 in. in thickness, the minimum distance shall be 2 in.

U-79. *Specifications for Testing Welds.* I. *Grade A Test Requirements.* *a Test Plates for Longitudinal Joints.* Two sets of test plates of the dimensions shown in Fig. 2[3] from steel of the same specifications as the drum plates, prepared for welding, shall be attached to the shell being welded, as in Fig. 1,[3] one set on each end of one longitudinal seam of each drum so that the edges to be welded in the test plates are a continuation of and duplication of the corresponding edges of the longitudinal seam in the shell. Weld metal shall be deposited in the test plates continuously with the weld metal deposited in the longitudinal joint of the shell. As an alternate method, detached test plates may be welded as in the case of circumferential joints.

b Test Plates for Circumferential Joints. When test plates are welded for the longitudinal joints, none need be furnished for circumferential joints in the same vessel provided the welding process, procedure, and technique are the same. Where a vessel has only circumferential joints, two sets of test plates of the same material as the shell shall be welded in the same way as a detached test plate for a longitudinal joint.

c The test plates shall be so supported that warping due to welding shall not throw the finished test plate out of line by an angle of over 5 deg.

Where the welding has warped the test plates, they shall be straightened cold before being stress relieved. No nozzle shall be attached by welding without stress relief as required by Par. U-75. The test plates shall be subjected to the same stress-relieving operation, as required by Par. U-75, preferably by placing within the parent vessel.

d Test Specimens. The inspector shall select one of the two welded test plates, from which the coupons for tension and bend tests and for specific-gravity determinations shall be removed as shown in Fig. 2.[3]

e Tension Tests. Two types of tension-test specimens are required, one of the joint and the other of the weld metal. The tension specimen of the joint shall be transverse to the welded joint, and shall be the full thickness of the welded plate after the outer and inner surfaces of the weld have been machined to a plane surface flush with the plate. When the capacity of the available testing machine does not permit testing a specimen of the full thickness of the welded plate, the specimen may be cut with a thin saw into as many portions of the thickness as necessary, each of which shall meet the requirements.

Each tension specimen should fail in the plate, but if failure occurs in the weld metal or along the line of fusion between weld metal and the plate, then the tensile strength shall not be less than the minimum of the specified tensile range of the plate used.

The tension-test specimen of the weld metal shall be taken entirely from the deposited weld metal and shall meet the following requirements:

Tensile strength = at least that of the minimum of the range of the plate which is welded;
Elongation, minimum = 20 per cent.

The dimensions of the specimen shall conform to those given in Fig. 3.[4] However, should it not be possible below certain plate thicknesses to obtain a specimen of the weld metal, this test may be omitted.

f Bend Tests. The bend-test specimen shall be transverse to the welded joint of the full thickness of the plate and shall be of rectangular cross-section with the width $1^1/_2$ times the thickness of the specimen. When the capacity of the available testing machine does not permit testing a specimen of the full thickness of the welded plate, the specimen may be cut with a thin saw into as many portions of the thickness as necessary, each of which shall meet the requirements. The inside and outside surfaces of the weld shall be machined to a plane surface flush with the plate. The edges of this surface shall be rounded to a radius equal to 10 per cent of the thickness of the plate. The specimen shall be bent cold under free bending conditions until the least elongation measured within or across approximately the entire weld on the outside fibers of the bend-test specimen is 30 per cent.

When a crack is observed in the convex surface of the specimen between the edges, the specimen shall be considered to have failed and the test shall be stopped. Cracks at the corners of the specimen shall not be considered as a failure. The appearance of small defects in the convex surface shall not be considered as a failure if the greatest dimension does not exceed $^1/_{16}$ in.

g Chemical Analysis and Specific Gravity of Weld Metal. Specimens shall be taken from the weld metal of the joints. A chemical analysis shall show not over 0.03 per cent of nitrogen as iron nitride, the nitride content to be determined by the modified Allen method of the Bureau of Standards (Scientific Paper No. 457, U. S. Bureau of Standards). The specific-gravity specimens shall, if possible, be 2 in. long and $^5/_8$ in. in diameter, as shown in Figs. 2[4] and 3.[4] The minimum specific gravity shall be 7.80.

NOTE: The Boiler Code Committee may omit one or both of these test requirements from the final specifications.

h Retests. Should any of the tests other than these specific-gravity tests fail to meet the requirements by 10 per cent or less, retests shall be allowed on specimens cut from the second welded test plate.

Should any of the tests other than these specific-gravity tests fail to meet the requirements by more than 10 per cent, no retests shall be allowed. The retest shall comply with the requirements. For either of the tension retests, two specimens shall be cut from the second test plate, and both of these shall meet the requirements.

[3] See MECHANICAL ENGINEERING, December, 1930, pp. 1096 and 1097.

[4] See MECHANICAL ENGINEERING, December, 1930, pp. 1056 and 1057.

When there are more than one specimen of the same type and when one or more of the group specimens fail to meet the requirements by 10 per cent or less, the retest shall be made on an entire group of specimens which shall meet the requirements.

Should the specific gravity obtained on the specific-gravity specimen be less than 7.75, no retest shall be allowed. Should the specific gravity lie between 7.75 and 7.80, a retest shall be allowed. The retest shall show a specific gravity of not less than 7.80.

i Non-Destructive Tests of Vessel. For plate thicknesses $2^1/_2$ in. and less, every portion of all longitudinal welded joints and of one circumferential welded joint, or one circumferential welded joint where there is no longitudinal joint, of the stress-relieved structure shall be radiographed by a sufficiently powerful X-ray apparatus under a technique which will determine quantitatively the size of a defect with a thickness greater than 2 per cent of the thickness of the base plate. Photographic prints of the X-ray films shall be submitted to the inspector. Vessels of a wall thickness over $2^1/_2$ in. need not be X-rayed until such a time as evidence is submitted to the Boiler Code Committee that the X-ray or similar means are developed that can be commercially applied to greater thicknesses. A manufacturer must demonstrate his ability to produce sound welds by constructing Class 1 vessels, and the joints of which are X-rayed, in order to be permitted to construct Class 1 vessels with a shell thickness over $2^1/_2$ in. without X-ray examination.

NOTE: The removal of the words "stress relieved" from this paragraph has been suggested in order to permit the X-ray examination of vessels before stress relieving.

It is contemplated that the manufacturer should demonstrate his ability to produce sound welds in unfired pressure vessels, the joints of which are X-rayed, of a thickness approaching $2^1/_2$ in. before being permitted to construct drums or shells of a thickness over $2^1/_2$ in. without X-ray examination. It has been proposed that the minimum thickness for demonstrating this ability be made 2 in.

Radiograph No. 1[5] shows the desired type of print in which the presence of the welded joint can be detected only with great difficulty. This type represents excellent weld metal with a specific gravity of 7.80 to 7.85.

Radiograph No. 2[5] indicates the presence of some porosity of the weld metal in the joint. This porosity, however, is not excessive, and radiographs of this type shall be acceptable.

Radiograph No. 3[5] represents a porous condition in the weld metal which is not desirable.

Radiograph No. 4[5] represents a serious defect in a welded joint. This defect represents a slag inclusion or cavity extending longitudinally along the wall of the joint. A radiograph of this kind indicates a weld that is not acceptable. However, a radiograph showing a defect of this kind in which the length of the defect is less than $^1/_3T$, where T is the thickness of the joint and where these defects are separated from each other by at least $2T$ of solid weld metal, indicates a weld that shall be acceptable, provided such defects shall not average more than one per foot for any one seam.

A description of the X-ray technique employed shall be submitted with the radiographic prints to the inspector, this record giving:

1 The thickness of the plate
2 The distance of the film from the rear of the joint
3 The distance of the film from the source of X-rays
4 The voltage impressed on the tube
5 The current flowing through the tube
6 The time of exposure
7 The type of film used
8 The type of intensifying screens.

The locations of the reference markers, the images of which appear on the film, shall be accurately and permanently stamped on the outside surface of the vessel near the weld so that a defect appearing on the X-ray print may be accurately located in the actual welded joint.

To determine whether the X-ray technique employed is detecting defects of a thickness 2 per cent or greater than the thickness of the base plate, a piece of sheet steel of a thickness equal to 2 per cent of the base plate and containing a hole shall be placed alongside the welded joint so that its image is obtained on the X-ray film but still does not interfere with the image of the welded joint. The image of the hole in the sheet should be obtained on the X-ray film.

II. *Grades B and C Test Requirements. a* Each manufacturer shall be responsible for the quality of the welding done by his organization and shall conduct tests of the welders to determine their ability to produce welds which will meet the required tests. An authorized inspector shall have the right at any time to call for and witness the making of test specimens by any welder and to observe the physical tests. The tests conducted by one manufacturer shall not qualify a welder to do work for any other manufacturer.

The tests of a welder made by the manufacturer shall be effective for a period of six months only, at the end of which time a repetition of the tests shall be made.

Each welder shall be assigned by the manufacturer an identifying number, letter, or symbol, which shall be stamped on all vessels adjacent to and at intervals of not more than 3 ft. along the welds which he makes either by hand or by machine, or a permanent record may be kept by the manufacturer of the welders employed on each joint which shall be available to the inspector, and in such case the stamping may be omitted.

The manufacturer shall maintain a permanent record of the welders employed by him, showing the date and result of the tests and the identification mark assigned to each. These records shall be certified to by the manufacturer and accessible to the inspector. (A sample data-report sheet appears on p. 466.)

b Test Plates. Class of Material. Material for test plates shall conform to Specification S-1 for Steel Boiler Plate, except that where other materials permitted for construction are employed for test plates, the tests for welders shall be considered as applying only to such materials.

Thickness of Material. Test plates shall be made in at least two thicknesses as follows:

For Grade B test requirements, $^5/_8$ in. and $1^1/_2$ in.
For Grade C test requirements, $^1/_4$ in. and $^5/_8$ in.

Where the maximum thickness employed in construction under these rules is less than the limit permitted in either Grade B or Grade C test requirements, test plates of the maximum thickness for which approval is desired, may be substituted for the $1^1/_2$-in. test plate in Grade B test requirements and the $^5/_8$-in. test plate in Grade C test requirements.

Where Grade B test requirements are to be employed for thicknesses less than $^5/_8$ in., a $^1/_4$-in. test plate shall also be made.

Type of Joint. For Grade B test requirements, the type of joint shall be the double-welded butt joint. For Grade C test requirements, the type of joint shall be the single-welded butt joint for the $^1/_4$-in. test plate and the double-welded butt joint for test plates having a thickness greater than $^1/_4$ in. The preparation of the edges of the test plate for welding shall be the same as to be employed in construction.

[5] See pages 1098 to 1100, December, 1930, MECHANICAL ENGINEERING.

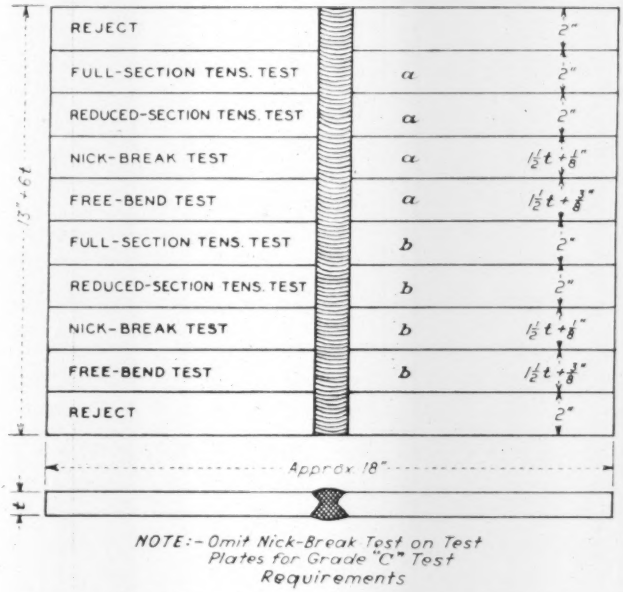


FIG. 4 TEST-PLATE DIMENSIONS AND SPECIMEN LOCATIONS

Procedure of Welding. The test plates shall be welded under the same procedure as to be employed for construction. The process of welding, size and type of welding rod, number of welding layers, position in which the welding is done, etc., shall be the equivalent of that to be used for construction. Only such accessories to or supplements of the welding procedure, for example, the employment of weld backing-up strips or reheating of the test plates for stress relief or heat treatment, shall be employed in the production of the test plates as will be required for construction.

External Appearance and Reinforcement of Weld. The external appearance of the welds and the amount of weld reinforcement shall conform to the requirements for construction, and the maximum reinforcement for the test plates shall not exceed the minimum required for construction.

Test-Plate Dimensions, Number of Test Specimens, and Specimen Location. Two full-section tensile-test specimens, two reduced-section tensile-test specimens, two nick-break-test specimens, and two bend-test specimens shall be required from each test plate, except that the nick-break-test specimens are not required for Grade C test requirements.

The required dimensions for the test plates and specimen location shall be as given in Fig. 4.

c Test Specimens. Full-Section Tensile-Test Specimen. The shape and dimensions of the tensile-test specimen shall be as shown in Fig. 5, with the weld at the center. It will usually be unnecessary to machine the top and bottom surfaces of the specimen. A 100,000-lb. capacity tensile testing machine will be satisfactory for testing all specimens. Swivel specimen holders should be used to insure, in so far as possible, axial loading. Data shall be recorded on the ultimate strength; stress (pounds per square inch) computed from the area of the base-metal section.

Reduced-Section Tensile-Test Specimen The shape and dimensions of the test specimen shall be as shown in Fig. 6. The top and bottom sides of this specimen should be machined to "clean up" the surfaces. The data to be recorded in connection with the reduced section tensile-test specimens shall be the same as for the full section tensile-test specimens.

Nick-Break-Test Specimen (for Grade B test requirements only). The shape and dimensions of the specimen shall be as shown in Fig. 7. The specimen is to be suitably supported as shown in Fig. 7 and broken by a sudden blow or blows applied at the center of the weld. The blow should preferably be applied by a power hammer or falling weight, and be of sufficient intensity to cause a sharp, sudden fracture of the specimen through the nicked portion.

Bend-Test Specimen. The dimensions of the specimen shall be in accordance with Fig. 8. The length may vary with the

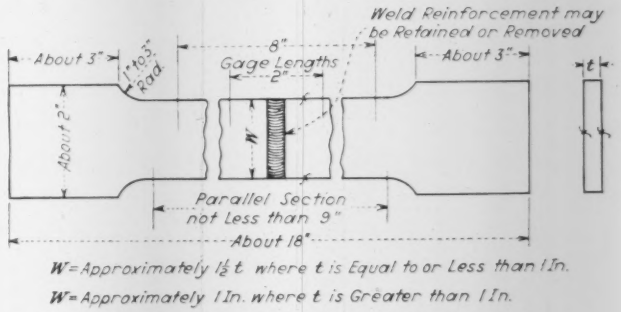

Weld Reinforcement may be Retained or Removed
About 3"
1" Rad.
8"
Gage Lengths
2"
About 3"
About 2"
Parallel Section not Less than 9"
About 18"
W = Approximately 1½ t where t is Equal to or Less than 1 In.
W = Approximately 1 In. where t is Greater than 1 In.

FIG. 5 TENSILE-TEST SPECIMEN

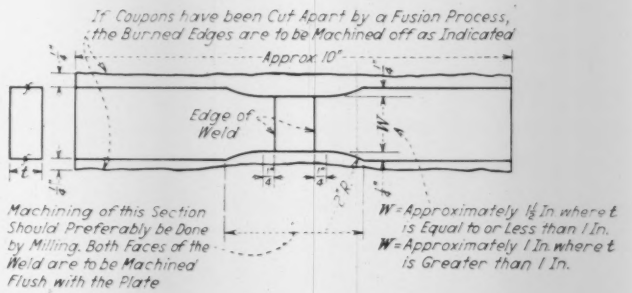

If Coupons have been Cut Apart by a Fusion Process, the Burned Edges are to be Machined off as Indicated
Approx. 10"
Edge of Weld
Machining of this Section Should Preferably be Done by Milling. Both Faces of the Weld are to be Machined Flush with the Plate
W = Approximately 1½ In. where t is Equal to or Less than 1 In.
W = Approximately 1 In. where t is Greater than 1 In.

FIG. 6 WELD-METAL TENSILE-TEST SPECIMEN

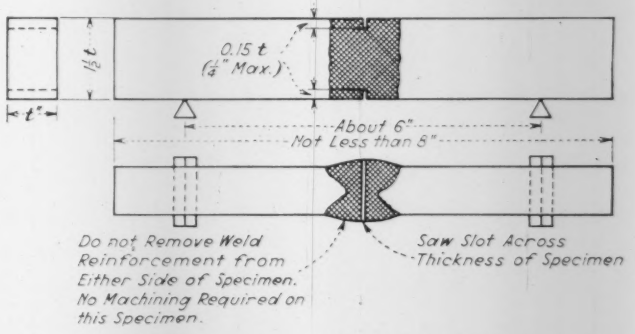

0.15 t (¼" Max.)
About 6"
Not Less than 8"
Do not Remove Weld Reinforcement from Either Side of Specimen. No Machining Required on this Specimen.
Saw Slot Across Thickness of Specimen

FIG. 7 SPECIMEN FOR NICK-BREAK TEST

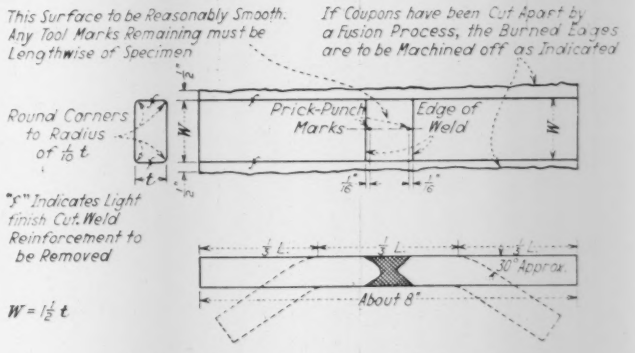

This Surface to be Reasonably Smooth. Any Tool Marks Remaining must be Lengthwise of Specimen
If Coupons have been Cut Apart by a Fusion Process, the Burned Edges are to be Machined off as Indicated
Round Corners to Radius of 1/16 t
Prick-Punch Marks
Edge of Weld
"X" Indicates Light finish Cut. Weld Reinforcement to be Removed
W = 1½ t
30° Approx.
About 8"

FIG. 8 SPECIMEN FOR FREE-BEND TEST

thickness of the piece and is unimportant, provided it is long enough to permit the bending operation. The bend in the specimen may be started by holding the specimen in a vise about one-third from the end, producing an initial bend at this point with hammer blows. Another bend about one-third from the other end may be produced in the same manner.

The specimen with the initial bend at each end is then placed as a strut in a vise or compression machine and pressure applied gradually (that is, without shock) at the ends until failure occurs in the outside fibers of the bend specimen. When a crack is observed in the convex surface of the specimen between the edges, the specimen shall be considered to have failed and the test shall be stopped. Cracks at the corners of the specimen shall not be considered as a failure. The appearance of small defects in the convex surface shall not be considered as a failure if the greatest dimension does not exceed $^1/_{16}$ in.

The performance of the specimen is evaluated by measurement of the outside-fiber elongation. This measurement may be made by means of a flexible scale. The elongation shall be recorded in per cent.

d Grade B Test Results. The minimum requirements for Grade B test results are as follows:

Tensile Tests. Each full-section tension specimen should fail in the plate if the weld reinforcement is retained, but if failure occurs in the weld metal or along the line of fusion between the weld metal and the plate, then the tensile strength shall not be less than the minimum of the specified tensile range of the plate used. For the reduced-section tension-test specimens the tensile strength shall not be less than 95 per cent of the minimum of the specified tensile range of the plate used.

Bend Test. The ductility requirement by the free-bend-test method shall be at least 20 per cent for electric-arc welding and at least 15 per cent for oxyacetylene welding.

Nick-Break Test. The nick-break test for soundness of the weld shall show in the fractured surface complete penetration through the entire thickness of the weld, absence of oxide or slag inclusions, and a degree of porosity not to exceed the following: Six gas pockets per square inch of the total area of the weld surface exposed in the fracture, the maximum dimension of any such pocket not to be in excess of $^1/_{16}$ in.

X-ray tests of the test plates may be substituted for the nick-break test.

Grade C Test Results. The minimum requirements for Grade C test results are as follows:

Tensile Tests. Each full-section tension specimen should fail in the plate if the weld reinforcement is retained, but if failure occurs in the weld metal or along the line of fusion between the weld metal and the plate, then the tensile strength shall not be less than 90 per cent of the minimum of the specified tensile range of the plate used. For the reduced-section tension-test specimen the tensile strength shall not be less than 85 per cent of the minimum of the specified tensile range of the plate used. In no case shall the tensile strength be less than 42,000 lb. per sq. in.

Bend Test. The ductility requirement by the free-bend-test method shall not be less than 10 per cent.

Specifications for Fusion Welding of Drums or Shells of Power Boilers

The rules for fusion welding of drums or shells of power boilers shall be the same as for Class 1 vessels in the Code for Unfired Pressure Vessels, except that the requirements for Non-Destructive Tests shall be as follows:

Non-Destructive Tests. For plate thicknesses of 3 in. and less, every portion of all longitudinal and circumferential welded joints of the stress-relieved structure shall be radiographed by a sufficiently powerful X-ray apparatus under a technique which will determine quantitatively the size of a defect with a thickness greater than 2 per cent of the thickness of the base plate. Photographic prints of the X-ray films shall be submitted to the inspector. Vessels of a wall thickness over 3 in. need not be X-rayed until such a time as evidence is submitted to the Boiler Code Committee that the X-ray or similar means are developed that can be commercially applied to greater thicknesses. A manufacturer must demonstrate his ability to produce sound welds in boiler drums or shells, the joints of which are X-rayed, in order to be permitted to construct boiler drums or shells with a shell thickness over 3 in. without X-ray examination.

NOTE: The removal of the words "stress relieved" from this paragraph has been suggested in order to permit the X-ray examination of vessels before stress relieving.

It is contemplated that the manufacturer should demonstrate his ability to produce sound welds in boiler drums or shells, the joints of which are X-rayed, of a thickness approaching 3 in. before being permitted to construct drums or shells of a thickness of over 3 in. without X-ray examination. It has been proposed that the minimum thickness for demonstrating this ability be made $2^1/_2$ in.

MANUFACTURERS' SAMPLE DATA REPORT FOR GRADES B AND C FOR TEST REQUIREMENTS

Manufacturer .....
Location ..... Date of Test .....
Welder ..... Symbol ..... Number .....
Grade of Welding ..... Welding Process or Trade Name .....

	Test Plate Number 1	2	3	4
1. Type of Preparation				
2. Thickness of Material				
3. Class of Material				
4. Position of Welding				
5. Size of Welding Rod				
6. Type of Welding Rod				
7. Amperage and Voltage				
8. Size of Welding Tip or Tips				
9. Number of Welding Layers				
10. Reinforcement				
11. Appearance of Weld				
Full-Section Tensile Test				
a. Lb. per sq. in.				
b. Lb. per sq. in.				
Reduced-Section Tensile Test				
a. Lb. per sq. in.				
b. Lb. per sq. in.				
Nick-Break Test				
a. Appearance				
b. Appearance				
Free-Bend Tests				
a. Per cent				
b. Per cent				

The undersigned manufacturer certifies that the statements made in this report are correct and that the test plates were prepared, welded, and tested in accordance with the requirements of the A.S.M.E. Code for Unfired Pressure Vessels.

Date ..... 19.. Signed .....
(Manufacturer)

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply is then prepared by the Committee and passed upon at a regular meeting of the Com-

mittee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 676 and 680–685, inclusive, as formulated at the meeting on March 27, 1931, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 676

Inquiry: Is it considered that an outside-screw-and-yoke type of globe cross-valve will meet the requirements of the Code when used as a shut-off in a connection to a water column; the valve to be similar in construction to the angle type of valve which causes no stoppage of flow by deposits of sediment and has a hand wheel attached to the rising and falling stem?

Reply: It is the opinion of the Committee that unless the valve stem of the type of valve described, is so arranged that it indicates clearly by its position whether the valve is open or closed, the construction will not meet the requirements of Par. P-293 of the Code. It is the further opinion that the opening provided between the seat and disk of the valve must be such that a full free opening is obtained. The construction of such a type of globe cross-valve interferes with proper cleaning of the water column connection and it is pointed out that erroneous installation of such a cross-type valve might create a hazardous condition.

CASE NO. 680

Inquiry: Will a steam-gage siphon which is formed to provide a water pocket between baffles in the body of the device, meet the requirements of the Code for Low-Pressure Heating Boilers if it is made of ferrous material, if its water capacity is not sufficient to insure that the gage tube will be kept full of water under all conditions of normal operation, if the connection between it and the steam gage is of $^1/_4$-in. diameter iron or steel pipe, and if it is installed so the water pocket is immersed in the steam space of the boiler?

Reply: The fact that the siphon is made from ferrous material does not, in the opinion of the Committee, violate the requirements of Pars. H-55, H-56, H-108 and H-109, if the area through the siphon is at least the equivalent of $^1/_2$-in. pipe size, and the distance between the gage and point of attachment of pipe is not over 5 ft. The siphon as described does not meet the requirements of Pars. H-55, H-56, H-108, and H-109 if the water capacity is not sufficient to keep the gage tube filled with water under all conditions of normal operation, nor unless all parts of the piping less than $^1/_2$-in. pipe size are of brass, copper, or bronze composition. It was not the intent of the Code to sanction the installation of a siphon with the water pocket immersed in the steam space of the boiler. A revision which will prohibit such installation is under consideration.

CASE NO. 681

Inquiry: With further reference to Case No. 672, are the plates into which the pressed steel diaphragm plates are inserted and welded to be classified as tube sheets or heads, under the meaning of Par. H-12, in which the minimum thickness requirement is $^5/_{16}$ in.?

Reply: It is the opinion of the Committee that where cross boxes such as the pressed steel diaphragm plates described are inserted in the slots in plates and welded therein, neither the boxes are to be classified as tubes, nor the plates in which they are inserted to be classified as heads as contemplated in Par. H-12.

CASE NO. 682

Inquiry: Is it the intent of Par. H-35, which requires that wet-bottom steel-plate boilers be so set that there will be a space of not less than 12 in. between the bottom of the boiler and the floor line, to cover a rectangular-shaped boiler of a width not to exceed 36 in. with water space below the furnace?

Reply: Par. H-35 was intended to apply to steel-plate heating boilers of the wet-bottom locomotive type. It is the opinion of the Committee that it should not apply to rectangular-shaped heating boilers of the type described, provided sufficient space is allowed beneath the bottom of the boiler for inspection. It is the further opinion of the Committee that if 6 in. clearance is provided for a boiler of the sort and the boiler is so set that all parts of the bottom can be thoroughly inspected, the intent of the paragraph will be met. A revision of the Code to embody this idea is contemplated.

CASE NO. 683

(In the hands of the Committee)

CASE NO. 684

Inquiry: Will a jacketed kettle of riveted construction meet the requirements of the Code for Unfired Pressure Vessels if the inner shell is formed of a nickel-chromium steel known as Enduro KA2, which has the following analysis and physical properties:

Carbon, maximum, per cent	0.07
Manganese, per cent	0.40–0.65
Phosphorus and sulphur, max., per cent	0.035
Silicon, per cent	0.30–0.75
Nickel, per cent	8.00–9.50
Chromium, per cent	17.50–19.50
Tensile strength, min., lb. per sq. in.	85,000
Yield point, lb. per sq. in.	40,000
Elongation in 2 in., per cent	55–60
Reduction in area, per cent	70–75

All other details would be designed to conform to Code requirements, but it is noted that the Code calls specifically for flange or firebox-quality steel.

Reply: It is the opinion of the Committee that an interrelation exists between the several Codes and although it is not specifically so stated in the Code for Unfired Pressure Vessels, Section VIII, the provisions in Par. P-1 of Section I of the Code, providing for the use of other materials than those for which specifications are given, is applicable to Section VIII. The Committee is further of the opinion that the material as above described is suitable for the particular use proposed.

CASE NO. 685

Inquiry: In the recent 1930 revision of the Code for Unfired Pressure Vessels, Par. U-87 has been so modified that it now requires the entire vessel to be stress relieved as a unit and the provision for local annealing of the forge welded joints has been omitted. However, fusion-welded joints are permitted by revised Par. U-72 to be stress relieved either locally or the entire vessel as a unit, and it is respectfully requested that Par. U-87 be made at least as liberal in its requirements as Par. U-72.

Reply: It is the opinion of the Committee that the provisions for stress relieving under Par. U-87 should be substantially in accordance with those provided for under Par. U-72. A revision is under consideration to make Par. U-87 substantially the same as Par. U-72.

Rolled Threads for Screw Shells of Electric Sockets and Lamp Bases

Proposed American Standard Embraces Five Sizes: Namely, the Miniature, Candelabra, Intermediate, Medium, and Mogul

AN ABSTRACT of the proposed American Standard for Rolled Threads of Screw Shells of Electric Sockets and Lamp Bases is published here for the information of the members of the A.S.M.E. This proposal represents a rearrangement of the specifications originally published in 1915 in the Transactions of the A.S.M.E. (vol. 37, pp. 25–29), with the addition of a specification for one new size.

It is interesting to note that the Edison type of base screw shell as covered by this proposal has been in use for nearly half a century. As early as 1888 the Edison Lamp Works made socket screw shells in accordance with a gage which differed from the present standard mainly in that it had a slight taper, but the pitch of the thread has remained unchanged from the beginning.

This proposed standard covers the dimensions, tolerances, and gages for rolled threads of Edison-type screw shells intended for use in the manufacture of lamp bases and plugs, and of lamp and fuse holders. These dimensions for the five sizes, miniature, candelabra, intermediate, medium, and mogul, are shown in the accompanying tables, while the thread form is illustrated in the figure given. These tables are prefaced in the standard by introductory notes which include the nomenclature, description of the thread form, and an outline of the gaging practice to be followed.

ROLLED THREADS FOR SCREW SHELLS OF ELECTRIC SOCKETS AND LAMP BASES

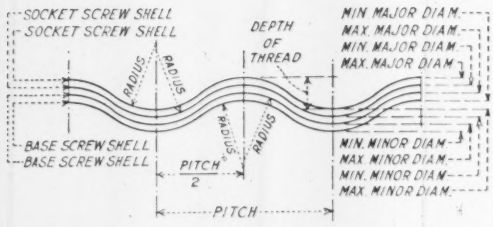


Table 1 Rolled Threads for Base Screw Shells Before Assembly

Size	Threads per Inch	Pitch	Depth of Thread	Radius	Major Diam.		Minor Diam.	
					Max.	Min.	Max.	Min.
Miniature	14	0.07143	0.020	0.0210	0.375	0.370	0.335	0.330
Candelabra	10	0.10000	0.025	0.0312	0.465	0.460	0.415	0.410
Intermediate	9	0.11111	0.027	0.0353	0.651	0.645	0.597	0.591
Medium	7	0.14286	0.033	0.0470	1.037	1.031	0.971	0.965
Mogul	4	0.25000	0.050	0.0906	1.555	1.545	1.455	1.445

All dimensions given in inches.

Table 2 Rolled Threads for Socket Screw Shells Before Assembly

Size	Threads per Inch	Pitch	Depth of Thread	Radius	Major Diam.		Minor Diam.	
					Max.	Min.	Max.	Min.
Miniature	14	0.07143	0.020	0.0210	0.3835	0.3775	0.3435	0.3375
Candelabra	10	0.10000	0.025	0.0312	0.476	0.470	0.426	0.420
Intermediate	9	0.11111	0.027	0.0353	0.664	0.657	0.610	0.603
Medium	7	0.14286	0.033	0.0470	1.053	1.045	0.987	0.979
Mogul	4	0.25000	0.050	0.0906	1.577	1.565	1.477	1.465

All dimensions given in inches.

The Sectional Committee on Rolled Threads for Screw Shells of Electric Sockets and Lamp Bases was organized in March, 1929, under the procedure of the American Standards Association, with the National Electrical Manufacturers Association and The American Society of Mechanical Engineers as joint sponsors. After a careful review of the 1915 A.S.M.E. specifications the Committee proceeded with the development of this proposal, a preliminary draft of which was distributed to industry in May, 1930. The comments received from this distribution have been taken into account in the preparation of the final-draft standard.

The personnel of the Sectional Committee is widely representative of those interested in the standardization of screw-shell threads and consists of the following members: R. E. Myers, Chief Engineer, Westinghouse Lamp Company, *Chairman;* A. Brann, Engineering Department, Westinghouse Lamp Company, Secretary; C. A. Bates, Commercial Engineer, Bryant Electric Company; M. M. Brandon, Associate Electrical Engineer, Underwriters' Laboratories, Inc.; E. J. Bryant, Manager, Gage and Reamer Department, Greenfield Tap and Die Corporation; E. Buckingham, Associate Professor of Engineering, Standards and Measurement, Massachusetts Institute of Technology; M. D. Cooper, Engineering Department, General Electric Company; H. A. Currie, Electrical Engineer, New York Central Railroad; G. L. Diggles, Superintendent, Lamp Inspection for Mazda Service; S. E. Doane, Chief Engineer, National Lamp Works, General Electric Company; B. H. Kenyon, Manager Providence Base Works, General Electric Company; G. S. Merrill, Engineering Department, General Electric Company; J. F. Meyer, Physicist, Bureau of Standards; H. G. Morgan, Signal Engineer, Engineering Department, Illinois Central Railroad; A. C. Recker, Chase Brass and Copper Company; H. B. Rogers, Incandescent Lamp Department, General Electric Company; E. S. Sanderson, General Sales Manager, Scovill Manufacturing Company; H. R. Sargent, General Electric Company; T. I. Walker, Providence Base Works, General Electric Company.

Copies of this standard may be secured by addressing C. B. LePage, Assistant Secretary, A.S.M.E., 29 W. 39th St., New York, N. Y., to whom all criticisms and comments should be sent.

Engineering and Industrial Standardization

Letter Symbols for Heat and Thermodynamics

A NEW American Tentative Standard, "Symbols for Heat and Thermodynamics" (Z10c-1931), has just been approved by the American Standards Association.

The standard is the result of extensive work by the Subcommittee for Heat and Thermodynamics of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations. This committee cooperated with the International Electrotechnical Commission and with the National Research Council in the preparation of the standard. A tentative list of the symbols was submitted to a subcommittee of the Advisory Committee on Steam Turbines of the International Electrotechnical Commission for discussion at a meeting at the Hague in 1928. A large proportion of the symbols in the list were tentatively adopted at that time by the Advisory Committee.

The symbols for heat transmission included in the present standard were adopted jointly by the Subcommittee on Symbols for Heat and Thermodynamics and by the Committee on Heat Transmission of the National Research Council following extensive correspondence between the two bodies.

The new standard will be of interest to power-plant designers, turbine-engine designers, boiler designers, and all others working with the problems involving the transfer and transmission of heat.

The sponsors for the Sectional Committee on Scientific and Engineering Symbols and Abbreviations are:

American Association for the Advancement of Science
American Institute of Electrical Engineers
American Society of Civil Engineers
Society for the Promotion of Engineering Education
The American Society of Mechanical Engineers.

The standard may be purchased for 30 cents per copy from The American Society of Mechanical Engineers, 29 West 39th Street, New York.

Certification and Labeling

FOR some years the National Bureau of Standards has advocated the use of its "Certification Plan" which is intended to popularize the products which manufacturers certify to be in accordance with specifications. Recently the National Electrical Manufacturers Association requested the American Standards Association to give consideration to this plan, and attached to this request a memorandum setting forth its views.

The request was considered by the A.S.A. Standards Council at its June, 1930, meeting, and later by its Board of Directors. The discussion in the Board centered largely upon the following questions:

(*a*) Are certification and labeling of goods as being in accordance with specifications desirable in general industrial purchasing and in "across-the-counter" goods?
(*b*) Are they feasible without explicit provision for policing?
(*c*) Is the trade association the proper agency for policing?
(*d*) Is it desirable that the movement furthering certification and labeling in various fields head up in an arm of the Government?

It was finally decided that the A.S.A. ought not to take a definite position on any of these far-reaching and interlocking problems without a thoroughgoing study of the whole subject of certification and labeling, and that the appointment of a special committee to study the subject should await a preliminary study of the subject by a committee of the Board of Directors consisting of:

HOWARD COONLEY, President Walworth Company, Boston, Mass., *Chairman*
GEORGE K. BURGESS, Director, U. S. Bureau of Standards, Washington, D. C.
C. L. COLLENS, President, Reliance Electric & Engineering Company, Cleveland, Ohio
F. E. MOSKOVICS, President, Improved Products Corporation, New York, N. Y.

A.S.A. Appoints New Assistant Secretary

THE appointment of Cyril Ainsworth as assistant secretary of the American Standards Association has just been announced by Bancroft Gherardi, president of the Association.

Mr. Ainsworth succeeds F. J. Schlink, assistant secretary for the last eight years, who recently resigned to give full time to the technical direction of Consumers' Research, Inc., a non-profit-making organization of which he was one of the organizers.

Mr. Ainsworth came to A.S.A. from the Department of Labor and Industry of the State of Pennsylvania, where he was director of the Bureau of Industrial Standards. Since that time he has been in charge of the entire safety-code program of the Association. He is also secretary of the committees in charge of the codes for walkway surfaces and for grandstands.

One of the most important phases of Mr. Ainsworth's work with the A.S.A. has been the promotion of the use of the national codes through cooperation with the groups concerned with accident-prevention work, state industrial associations, technical and trade associations, casualty-insurance organizations, and state commissions.

Mr. Ainsworth studied mechanical engineering at Swarthmore College and at Carnegie Institute of Technology. His industrial experience began with the Pennsylvania Railroad where he spent three years as a member of the engineering corps in the Engineering and Construction Department. He was for two years safety inspector of the United Gas Improvement Company, Philadelphia. In 1922 he joined the Department of Labor and Industry of Pennsylvania as safety engineer of the Industrial Board. He became successively secretary of the Industrial Board, director of the Bureau of Inspection, and director of the Bureau of Industrial Standards.

Prior to joining the staff of A.S.A., Mr. Ainsworth served on 15 national safety-code committees and was able to bring to these committees the experience gained through the enforcement and development of safety codes by a governmental agency.

Local Representatives of A.S.A.

EDWARD O. OTIS, JR., of Boston merchandising adviser of the Associated Industries of Massachusetts, and C. W. Whitney of San Francisco, Executive Secretary of the Purchasing Agents' Association of Northern California have been appointed as the Massachusetts and California representatives of the American Standards Association and will serve as contact points

between the industries of their respective states and the association. A file of the 181 national standards approved by the A.S.A. is maintained by each of the local representatives for reference by local engineers and industries.

Other local representatives of the American Standards Association are:

E. S. Strickland, Executive Secretary, Engineering Society of Buffalo, Buffalo, N. Y.
Edgar S. Nethercut, Secretary, Western Society of Engineers, Chicago, Illinois.
C. R. Sabin, Manager, Cleveland Engineering Society, Cleveland, Ohio.
Bernard Moll, Secretary, Grand Rapids Engineers' Club, Grand Rapids, Michigan.
Charles E. Billin, Secretary, Engineers' Club of Philadelphia, Philadelphia, Pa.
K. F. Treschow, Secretary, Engineers' Society of Western Pennsylvania, Pittsburgh, Pa.
O. L. Angevine, Executive Secretary, Rochester Engineering Society, Rochester, N. Y.
George S. Wilson, Engineering Experiment Station, University of Washington, Seattle, Wash.

Prevention of Dust Explosions

THE approval of the American Standards Association has been given recently to a Safety Code for Prevention of Dust Explosions in Coal Pneumatic Plants. This action is unique in the history of the safety movement since it constitutes the recognition of a national accident-prevention code for a process in which not a single serious accident has yet occurred. The new code is aimed at the prevention of dust explosions in pneumatic cleaning plants for coal. Practically all coal was formerly washed with water. It was found, however, that cleaning could be done more efficiently with air.

Each of the fifty other national safety-code projects completed or in process of development under the auspices of the A.S.S. has followed a long series of fatalities or injuries or a spectacular disaster which led the industry concerned to request the establishment of a safety code. In the case of coal pneumatic-cleaning plants, the use of which started only a comparatively few years ago, however, there has not been a single serious dust explosion. Nevertheless it was the belief of the industry and of safety experts that the potential hazard was great enough to warrant the development of a national code which would provide every possible safeguard against such explosions.

The work on the preparation of the code was carried on by a technical committee under the joint sponsorship of the U. S. Department of Agriculture and the National Fire Protection Association. This technical committee has also completed safety codes for the prevention of dust explosions in grain elevators, flour and feed mills, starch factories, pulverizing systems for sugar and cocoa, and in pulverized-fuel systems. The code contains comprehensive provisions for the construction and ventilation of buildings in which pneumatic screening and cleaning equipment and driers are located, and for the safeguarding of equipment and methods of dust collection.

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

High-Pressure and High-Temperature Steam for Locomotives

To the Editor:

The paper by C. F. Hirshfeld entitled "High-Pressure and High-Temperature Steam for Locomotives" gives few comparative data and does not point the way toward a specific solution of the steam-locomotive design problem. However, it does exactly what its author intended, in that it focuses attention upon the entire question of the future development of railway motive power. The writer believes this development to be one in which the steam locomotive will play a part—perhaps an important part—but will not necessarily be the center of attention.

For some years past, independent designers have been attempting to improve the locomotive as a power plant by the introduction of radical changes in thermodynamic design apart from the improvements which have been made upon the conventional design by most railroads. As far as this writer knows, however, no locomotive has yet been built which incorporates every possible advanced idea in its construction.

The writer believes that right at this point lies the very heart of the question of the most desirable form of railway motive power. The business of the railways is to furnish transportation in competition with waterways, highways, and airways. It is very doubtful if the railways should continue to depend, for their production of transportation, upon a more and more complex steam power plant on wheels. The more complex the steam plant, the more complicated becomes the control necessary to achieve high thermal efficiency. The railroads need higher sustained speeds, greater train loads, more intensive use of existing tracks, and continued high standards of safety. They need motive-power units which meet these requirements and which are able to stand the stress of traffic. It should be the business of the workers who operate these units to get the trains over the roads, not to be power-plant supervisors. Locomotives should be more automatic in their operation, not more complicated.

Assume that the seventy-odd thousand steam locomotives did not exist as tangible pieces of physical property, influencing the decisions of their owners on questions of future policy. What characteristics would railway men most desire in their motive power? The answer would be high sustained capacity, high acceleration rate, definitely high efficiency of energy conversion, favorable effect on roadbed and structures, low maintenance cost, easy adjustment to regional location, ease of control, small outage time, high mileage. On this basis the steam locomotive would hardly continue to occupy its present position, even though it were radically changed and improved.

If steam-locomotive design is going to "turn the corner," if designers are going to wipe the slate clean and do what central-station designers have been doing, then the railways might as well go all the way and turn their attention, not to the development of more complex mobile steam power plants, but to motive-power units considered as movers of traffic. Any railway which is financially able to install steam locomotives of radically changed design on a big scale (with attendant major changes in shop

equipment, etc.) is probably strong enough to turn about face to some other form of motive power which will have operating advantages as a producer of transportation far beyond those of even the most radically improved steam locomotive. Why spend money to achieve higher thermal efficiency when an easier and more nearly satisfactory solution to the real problem of traffic control lies closer at hand? First cost will be high in either case, and subsequent operation will reveal the greater economy of a motive-power unit designed primarily as a traffic mover rather than as a power plant on wheels.

R. P. KOLB.[1]

Pneumatic Tubes

TO THE EDITOR:

Exception is taken to the section concerning pneumatic tubes on page 16 of Transactions MH-53-1. These paragraphs may mislead members of the Society concerned with writing specifications and those interested in the patent phase of the pneumatic-tube art.

The "Pneu-Art" terminal illustrated in Fig. 37 is what the trade calls a "closed-receiver" type. This model was brought out in 1928 or 1929 at the latest. The writer is sure that the author of the section in question did not mean to say that this terminal required years of experimenting or that it was a part of 1930 progress.

About 1891 or 1892, two patents were issued and the drawings showed rectangular cabinets in a wall. Carriers were received and dispatched from inside the cabinet or terminal box.

Somewhere among the old patents is shown a closed receiver with an electric signal lamp attached to indicate the presence of a carrier within the terminal.

In the 1890's there were used, in New York, closed-receiver terminals made of glass after the fashion of a showcase.

About 1916, a bank located on Wall Street at Broadway, in New York, had a rectangular closed-receiver terminal made of plywood and recessed in the wall. It, too, had a signal lamp.

When the building on the southeast corner of 45th Street and Madison Avenue, New York, was erected, in the winter of 1917–19, the Equitable Trust Company installed a tube line. In the tellers' cage on the first floor was installed a closed receiving and sending terminal, set flush in the wall, that had a signal to announce a carrier within the local terminal and also one to indicate the arrival and removal of a carrier dispatched to the remote terminal. The terminal box had a bronze front and leather-padded door.

About 1922 the Lamson Company brought out their Junior System. The terminal cabinet was made of sheet steel and of rectangular shape large enough to hold a small motor and blower. The carrier was received and dispatched inside the box. It was finished either in a plain color or grained to imitate wood.

Samuel Olson & Company, of Chicago, sell a rectangular closed-receiver terminal, made of sheet metal and finished as desired, that is equipped with a semaphore signal so one may know a carrier has arrived.

There are eight or more pneumatic-tube manufacturers in this country, and inquiry might develop that others are making closed-receiver terminals. It has been the practice for years to conceal senders and receivers in cupboards.

J. G. MACLAREN.[2]

[1] Assistant Professor of Mechanical Engineering, North Carolina State College of Agriculture and Engineering, Raleigh, N. C. Mem. A.S.M.E.

[2] The MacLaren Company, Manufacturers' Agent, San Francisco, Calif. Mem. A.S.M.E.

Conference on Industrial Relations

A CONFERENCE on preparing engineers and business-school students to deal with industrial relations, was held on March 28, 1931, at the home of S. A. Lewisohn in New York, to provide opportunity for discussion of methods and interchange of experience among the men engaged in teaching courses in this pioneer field.

The conference was the immediate consequence of the report of the Committee on Industrial Relations of the S.P.E.E., presented at Montreal last June, which in discussing the question, "Can the Engineering Student Be Taught to Manage Men?" brought out the importance of teaching which will cause the student to become more sensitive to the human factors in his experience and give him a method of approach to problems of human relations.

One of the striking characteristics of the recent conference was the advance made since two earlier conferences. Two years ago the conference confined itself almost wholly to discussing the desirability, and even the practicability, of such teaching. This year there was such complete assent on this point that the conference took it for granted and settled down immediately to discuss objectives, subject-matter, and methods.

"To prepare students to learn from experience to deal with and manage men and industrial relations, not to produce managers ready made," was concurred in as the underlying objective of all such courses, in a discussion initiated by Elliott Dunlap Smith, professor of industrial engineering at Yale, and Joseph H. Willits, professor of industry at the Wharton School, University of Pennsylvania. The particular aims of such teaching should therefore be (1) to give students an orderly background in regard to industrial relations, which will enable them to see their problems in perspective and be the basis of a sound philosophy; (2) to make them more aware of and sensitive to the human factors in their work; and (3) to develop in them habits of objective, penetrating analysis of their problems of human contacts and of industrial relations.

In discussing subject-matter, Joseph W. Roe, professor of industrial engineering at New York University, and Ordway Tead, lecturer in the school of Business at Columbia University, emphasized two types of material: on the one hand, that relating to the history, scope, organization, practices, and social significance of industrial relations; and, on the other, that relating to individual human contacts and management. Both added that an understanding of human relations would be aided by vigorous study of the psychology of every-day behavior, taught, not as a dry, dissected thing, but as principles underlying the action of living men and groups.

This emphasis on reality was carried forward in the discussion of method lead by Prof. Herman Feldman of the Tuck School at Dartmouth, Prof. John R. Bangs of Cornell, Prof. John Younger of Ohio State, and Prof. E. H. Schell of Massachusetts Institute of Technology. While they stressed the importance of flexibility in method, and its subordination to the requirements of the particular course and situation, they also indicated the importance of employing methods that as far as possible exposed students to problems, cases, or experience, and caused them to think for themselves in regard thereto, emphasized.

The conference, which was presided over by C. E. Davies, Assistant Secretary of the A.S.M.E., appointed a committee to arrange for a similar gathering next year. The members of the conference were the guests at dinner of Mr. Lewisohn, who introduced as speakers, Gano Dunn, president of the J. G. White Engineering Corporation, and F. W. Willard, assistant works manager of the Western Electric Company. Both speakers stressed the importance of right social thinking on the part of engineering graduates.—ELLIOTT DUNLOP SMITH.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

The American Society of Mechanical Engineers

29 West 39th Street, New York

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American Engineers in Russia

LAST month we reprinted portions of a report issued by a committee of the A.I.M.E. on the status of the American engineer in Russia. The May issue of *Civil Engineering*, published by the A.S.C.E., contains a report on the same subject prepared by a committee of that society. In addition to the factors discussed in the A.I.M.E. report, that of the A.S.C.E. says that "it seems certain that neither American engineers nor American engineering firms occupy the preferential position enjoyed one and two years past." The report concludes with the following: "The Committee believes that, up to this time, there has been no ground for real or serious complaint on the part of those employed. The Committee believes, however, that no prediction is possible as to the length of time or the degree to which the present attitude of good will toward Americans will continue."

The Piece-Work System of Wages in Russia

FROM the beginning the managers of the destiny of Russia, in their serious effort to make a success of the so-called Five-Year Plan, have sought ways to increase productivity. More recently, group incentives have been resorted to. The adoption of the piece-work system, introduced practically at the beginning of the plan in works of key importance, has shown an earnest desire to make the plan succeed at all costs. Essentially the piece-work system of wages is contrary to all the teachings of socialism. It is criticized as being one of the principal methods by which capital succeeds in working labor to the utmost. However, it presents a powerful incentive toward increased production, particularly in a country where wages are as low as they are in Russia.

One of the results of the introduction of the piece-work system has been an intensified interest of the workmen in the operation of the mills. In many plants workmen have representatives on the committee managing the plant, or have committees that have the right to inspect all sections of the plant. An instance of this kind, apparently one of many, is reported in a Russian journal recently received in this country, and deals with the electrical works in Leningrad. Here the inspection committee visited the Lamp Department, which was behind on orders. They found that the glass bulbs supplied by another plant were often defective and improperly sized, that the tubes containing the lead-in wires were of improper manufacture, that metal parts were not right, the machinery was not in good shape, etc. Every statement is supported by evidence gathered during the visit of inspection, and is expressed with an astounding frankness.

Developments in Modern Elevators

IT WAS the elevator that made the skyscraper possible. Of late, because of the rise in the value of real estate due to the natural growth of cities, the climb of the upper stories of office buildings toward the clouds has been most spectacular. Buildings like the Bank of Manhattan, the Chrysler, and the Empire State as yet tower above the skyline of New York, but there is a general tendency to raise the whole skyline. With this growth in height have come developments in elevators.

Engineers of a large steel company have computed that, so far as strength of materials is concerned, it would be possible today to build a structure 18,000 ft. high. However, such a building would consist of little but elevators, with the result that there exists at present a fairly well determined maximum height. To keep pace with the demand for better elevator transportation in tall buildings, a revision of the elevator code in New York City has been suggested that will permit an increase in maximum speed of elevator cages from that allowed at present to 1200 ft. per min., and that will make it possible to run either double-cage elevators or two cages in the same shaft, operating the lower cage as a local and the upper cage as an express elevator. Elevators operating at the higher speed will be available as soon as they are legally sanctioned, and there has already been installed an elevator system consisting of two cages in a single shaft and provided with an elaborate interlocking system of controls which makes it practically impossible for one cage to collide with the other. A further development suggested by a recently constructed automatic garage, is a system of elevators with cages going up in one shaft and coming down in another.

It is only by such developments that the percentage of rentable space now occupied by elevators can be reduced, thus making the operation of tall structures more profitable and enlarging the sphere of their possibilities. The matter is of interest to the entire engineering profession because of the large amount of mechanical and electrical equipment employed in every tall building.

The V.D.I. 75th Anniversary

THIS month, the Verein deutscher Ingenieure, the Association of German Engineers, celebrates its 75th Anniversary at Cologne, Germany. The V.D.I. was founded in 1856 by 23 enthusiastic engineers, none of whom was more than 30 years of age. Since then it has grown to a membership of 31,000.

The object of this distinguished society has been "to coordinate the efforts of the best technical brains for the benefit of the whole industry of the country." In common with other societies organized for similar purposes, the V.D.I. has attained this object

by providing a forum for engineers in its meetings, lectures, and publications. Embracing a wide range of engineers in its membership, it has had the benefit of a greater cooperation toward common aims than is possible where many societies of specialists exist side by side. Its world-famous *Zeitschrift*, now in the 75th year, has been a periodical eagerly read in all countries. The material offered for publication in this magazine has become so extensive that numerous others, each devoted to some particular branch of engineering, have been established from time to time by the V.D.I. Research, codification of engineering practices, standardization, and collaboration with workers in other and allied fields have been generously fostered by the Verein, and have placed it in a well-deserved position of leadership in the profession.

Conscious of the benefits that have been derived from this great body of co-workers, engineers in this country extend hearty felicitations and congratulations on the occasion of this anniversary. The fundamentals of engineering are the heritage of all creative minds, whatever their nationality, that undertake the lifting of the burdens of toil and the extension of man's control over his physical environment. To the humanitarian purposes and ideals of engineering, all of its practitioners owe allegiance, and in the spread of its beneficences all cooperate. The task lies largely ahead, for only a beginning has been made. Therefore, in the spirit of those youthful founders of the V.D.I., symbolized by the statue of the young man, unveiled last month at Alexisbad, in the Harz mountains, where this great fraternity had its birth 75 years ago, it is a fitting time for engineers everywhere, like those pioneers, to fix their gaze upon the distant objectives of the profession and to repeat the challenging cry that thrilled those young hearts, "Now, to work!"

German Research in Science and Engineering

WHEN the post-war reconstruction period ended, Germany found itself industrially and economically in a position very different from that which it occupied before August, 1914. Its great resources of liquid capital were exhausted and its currency was undergoing the stabilization created by the so-called Dawes plan. The great supremacy of Germany in the fields of chemistry and finer mechanics had gone, its markets abroad had disappeared, and international shipping had been very nearly destroyed.

In the ten years which have passed since then great changes have taken place. Germany has reorganized its commercial shipping and placed it practically where it was before the war, with the single but important limitation that today it is less profitable than formerly. Germany has also recovered some of its export trade, although by no means all, heavy metals and heavy chemicals, particularly, remaining in the hands of competitors. But with the loss of capital and because of developments which have taken place elsewhere since the war, Germany is faced with the greatest difficulty in attempting to wrest the market for standard goods from its more fortunate competitors.

It is chiefly in the field of speciatlies that Germany may hope to succeed in the world's markets, and specialties means research and invention. Germany is therefore turning to research and science with more energy than ever before, and what is more, an effective organization has been achieved to control German research and prevent unnecessary duplication. This organization is headed by two great units, the Notgemeinschaft der Deutschen Wissenschaft (Emergency Union of German Science) and the Kaiser Wilhelm Society. The former was organized in 1920 purely as an emergency measure to make it possible to resume scientific work ruthlessly broken off by the thunder of guns. A primary purpose of the Notgemeinschaft was to make available to German scientists books and periodicals published abroad during the six years of the war and post-war periods, and to provide financial support for the more important scientific periodicals which in those days were faced with suddenly rising production costs and the falling value of the mark.

The Notgemeinschaft is chiefly concerned with research in pure science, including historical and archeological excavation, geography, and geology. The field of applied science and engineering falls within the purview of the Kaiser Wilhelm Society.

Up to the time of the war there was reluctance on the part of German plants to grant licenses under their patents to foreigners. When a foreign country presented a sufficiently good market the Germans organized local companies either as independents, with controlling stock held in Germany, or as subsidiaries of German concerns. Today capital is lacking for such enterprises, and the Germans are not only willing but often anxious to license foreigners under their patents. Undoubtedly many of these have proved highly profitable to the German concerns. Brains can be profitably exported if a sufficient amount is available.

Metals at High Temperature

A GENERATION or so ago, when a designer had at his command a few standard materials, he knew what to expect of them, when he should substitute cast steel for cast iron, when to use cold-rolled steel, where bronze was to be preferred to cast iron or babbitt, and forged steel or wrought iron to a casting. Today the metallurgists, spurred into action by the demands of automobile designers, power-plant and refinery engineers, and the chemical industries, have changed all that. The modern engineer has at his command a countless number of materials of widely varying characteristics, and while this makes his problem easier because he may choose one better suited to his purpose, there is laid upon him the obligation of knowing a great deal more about the mechanics and properties of materials than ever before.

Necessity has been the mother of invention as always. Materials that were satisfactory at low pressures and temperatures were useless in the ranges in which engineers wished to operate, and hence the designer was balked in his purposes. Strength, corrosion, and deformation characteristics proved unsuitable for those who wished to use highly superheated steam, or who were developing oil-refinery equipment. Makers of valves and pipe fittings, and the steel and other metallurgical industries, faced with these conditions, developed their research staffs to a point where new materials were made available and their properties and those of other materials at high pressure and temperatures, under corrosive actions, and under fatigue stress, became better known. To keep pace with the expanding knowledge has been a serious duty of the designer.

The engineering societies have given encouragement to programs of research in the properties of metals at high temperatures and have published as much of the literature on the subject as has been presented to them, within the limitations of their budgets. They have organized symposiums at which workers in this field could interchange data and ideas, and their meetings have offered splendid opportunities alike to those who are competent to instruct and those who are eager to learn.

The American Society for Testing Materials and the A.S.M.E., through their joint committee on the Effect of Temperature on the Properties of Metals, have prepared a symposium on High Temperature, to be held at the A.S.T.M. meeting in the Hotel Stevens, Chicago, Ill., June 23. The thirty papers that have been prepared will not be read individually nor will they be abstracted at the meeting. Instead there will be one general summary of the papers on engineering trends and needs at the first session, and one on metallurgical properties at the second, after which the

subject will be thrown open for general round-table discussion. This seems like a practical method of dealing with important and complicated subject-matter, inasmuch as those who attend the sessions are likely to have brought to their attention the most significant phases of recent developments. The papers themselves can be read at leisure by those interested.

Petroleum Mechanical Engineering

TWO important meetings within the past year have served to emphasize the importance of the mechanical engineer to the petroleum industry and have given especial significance to the term "petroleum mechanical engineering." The first of these was the meeting of the Petroleum Division of the A.S.M.E. at Tulsa, Okla., last October, for which a special issue of preprints of papers was prepared, and the second was the recent refinery meeting of the same division at Elizabeth, N. J., May 5 and 6.

The Tulsa meeting called attention particularly to the need for mechanical engineers in the production of petroleum. Here they come into contact with mining engineers and geologists, and with the chemists who are associated with the oil fields. To mechanical engineers familiar with power plants and manufacturing establishments the conditions under which engineering is carried out in the oil fields seem strange. Methods are simple, effective, productive of quick results, frequently crude. Time is an essential element, and locations and operating conditions are not ideal for highly developed and economical machinery. The latitude of the unknown factor is wide. Opportunities for research and design are enormous. The equipment, most peculiar to the industry, must meet severe requirements. But the fundamentals of engineering are adaptable, and great benefit is to be derived by applying them as thoroughly as conditions warrant.

At Elizabeth, mechanical engineers came face to face with another branch of the petroleum industry, the refinery, and here they joined hands with the chemist and the metallurgist. Refineries are more permanent in their location and use than is oil-field apparatus. Nice problems of chemistry and thermodynamics, of pressures and temperatures, of vaporization and condensation, of heat transfer and heat exchange, of metallurgy and mechanics, of operation and maintenance, abound. Here also is a field in which much work is to be done.

The discussion on Tuesday afternoon over the proposed specifications for the acceptance of heat-transfer equipment demonstrated the great need that exists for such a code. No one knows what a clean heat-transfer surface is. No one knows how to define a standard "dirty" surface. Heat-transfer coefficients, depending as they do upon the film resistances that vary with the dirtiness of both sides, decrease rapidly with use. The refiner is not interested in how a new, clean surface will perform, because it never lasts. The average condition confronts him, and it is on such a basis that he wishes guarantees. The proposed specifications aim to provide this basis. With them, performance as well as price will be the basis of purchase of heat-transfer equipment.

The refinery has long led the field in the use of metals at high pressures and temperatures and of welded vessels. The physical properties of metals under these conditions, combined with fatigue stresses and severe corrosive actions, are of utmost importance to refinery engineers where so much piping and so many valves, stills, and other equipment must be provided and subjected to long, severe, and continuous service. Wednesday's session gave an opportunity for the discussion of these important aspects of the refinery engineer's job.

One other important feature of the petroleum industry was brought out on Tuesday night at an after-dinner talk. Chemistry lies at the basis of the industry. While most of the research in universities has been directed to the chemistry of the coal-tar industry rather than the petroleum industry, the latter is by far the more important commercially. Chemists are just beginning to learn what may be accomplished by a rearrangement of carbon and hydrogen atoms in the products from petroleum crudes, but the indications are that many valuable compounds having useful characteristics may be developed commercially. Chemists did notable work in separating coal-tar derivatives. The mineral oils have always been looked upon as less susceptible to exploitation. Evidence now seems to be that petroleum may yield as rich and varied an assortment of products as have the coal tars, and that these two sources of hydrocarbonaceous substances may not be as dissimilar as was once supposed. There are interesting days ahead for the chemist, and as he develops more products, he will need more engineers to construct and operate his plants.

The National Industrial Congress

THE National Industrial Congress, held at the Cleveland Auditorium, April 13 to 17, called attention to three important phases of engineering: management, maintenance, and materials handling. In connection with it was held the Second National Industrial Equipment Exposition that afforded an opportunity for the display and study of considerably more than one hundred exhibits of machinery and equipment pertinent to the subject matter of the Congress.

Management, maintenance, and materials handling are so closely allied to the great problem of production as to be inseparable from it. Modern craftsmanship, which is represented by machine operations, the technologies of processes essential to the manufacture of goods, materials of construction, and the machines themselves are of small avail without the coordinating art of management, the insurance against deterioration provided by adequate maintenance, and the quickening vitality of an easy and uninterrupted flow of materials. Those elements of all successful production schemes are sufficiently fundamental to demand individual study, because failure to give them adequate attention will result in industrial failure. Particularly this year, as was brought out time and again at Cleveland, are these factors that affect costs vitally important.

An emphasis on waste, both in the addresses and in the exhibits, was an indication of the growing interest that this subject has for engineers. The statement of one engineer to the effect that there is no such thing as unpreventable waste was amply demonstrated by examples he was able to quote; and the figures of savings accomplished by thorough study by men trained to detect and eliminate wasteful practices that those familiar with a given shop's operations accepted as unpreventable or were blind to, were impressive.

In this connection attention should be called to an excellent pamphlet, issued for the first time at the Cleveland Congress, and the result of the work of the A.S.M.E. Management Division, namely, the "Waste Materials Dictionary." In an alphabetized list of waste materials, suggestions are given as to the uses to which each may be put. These suggestions were compiled from the practices of more than forty leading manufacturers. Before throwing out or otherwise disposing of any waste material, reference should be made to the "Waste Materials Dictionary."

A problem hitherto infrequently discussed at engineering meetings is that of the application of the principles of management to drafting-room organizations. Setting tasks and controlling their progress is not as simple a problem as that in connection with repetitive manufacture. The value of set tasks and recorded performance in stimulating production is nevertheless as great in one case as the other. The problem has been worked

out satisfactorily in some drafting rooms, as was indicated at Cleveland.

Listening to discussions on waste and maintenance, one is impressed with the importance of small items that assume staggering totals in large plants over long periods of time. Here the size of the staffs and budgets mark waste elimination and plant maintenance as departments of major importance. The administration of these departments affects those elements of ultimate cost in manufacture that may increase or consume the profits. Any long-range view of industry must consider them, particularly in view of the narrowing margins that modern economic conditions provide.

The interest shown in maintenance engineering at the Cleveland Congress demonstrated that to a considerable body of engineers this is a major responsibility, and a valuable collection of experiential data is being accumulated as a basis for its rapidly growing technology. Maintenance engineers control a considerable portion of the so-called non-productive or indirect expense. Maintenance implies insurance against costly interruption in production and preventable inefficiency of plant and equipment. As an item of expense, therefore, it is difficult to balance it against the major and minor disasters that good management has prevented. Its administration demands an imaginative and resourceful engineer backed up by a well-organized and versatile staff.

With mass production has come the conveyor assembly line with its accessory materials-handling features. Extension of plants over large areas and high costs of ordinary labor whose brute strength formerly provided the motive power for the continuous lifting and hauling that goes on in all industries, have contributed to the rapid development of mechanical handling methods. Of these many examples were witnessed at Cleveland, in the plants visited, in the Exposition itself, and in the papers and discussions at the Congress. Orderliness, labor saving, and the gearing of individual productive capacity to the speed of the conveyor are some of the striking changes that have come into the manufacturing industries as a result of this mechanization of the handling problem. The workman has been left only the functions that human skill alone can perform. The husky who lifted and carried remains only in the works of artists who find themselves unable to express human industry without emphasizing almost extinct forms of back-breaking toil.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the Engineering Foundation, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

A.S.T.M. Standards

AMERICAN SOCIETY FOR TESTING MATERIALS—STANDARDS. Issued Triennially. Published by the Society, Philadelphia, 1930. Cloth, 6 × 9, tables and illus., Part I, Metals, 1000 pp., $7.50; Part II, Non-Metals, 1214 pp., $7.50; both volumes, $14. (Half leather, $9 per volume, $17 for both volumes.)

AMERICAN SOCIETY FOR TESTING MATERIALS—TENTATIVE STANDARDS. Published by the Society, Philadelphia, 1930. Cloth, 6 × 9, 864 pp., illus., diagrams, tables, $8. (Paper, $7.)

EVERY three years the American Society for Testing Materials issues its "Book of Standards." This publication contains all specifications, methods of test, and definitions which have been fully approved and adopted by that society up to the year of publication.

PART I—METALLIC MATERIALS

Of the 179 standards on metals published in Part I, 105 cover the ferrous metals—steel, cast iron, wrought iron, alloy steel, and ferroalloys; 67 relate to the non-ferrous metals—nickel, copper, aluminum, etc., and many alloys; while 7 are of general interest.

The Standards in Part I, assembled in a sequence determined by the specific materials or products to which they apply, cover steel rails and accessories; wheels and tires; structural and boiler steels; steel for welding; concrete reinforcement steel; bar steels; spring steel and springs; steel castings, chain forgings, and axles; steel tubes and pipe; tool steel; steel for high-temperature service; zinc-coated wire and wire products; wrought-iron bars, castings, plates, and pipe; pig iron; cast-iron and finish castings, malleable castings; and ferroalloys. The specifications in the non-ferrous group cover ingot copper, zinc, lead, nickel, aluminum, and aluminum alloys, copper wire and cable, brasses and bronzes, solder metal, white-metal bearing alloys, and copper and brass plates and tubes. Methods are also included for Brinell hardness tests, metallographic testing, preparation of micrographs for metals and alloys, and a recommended practice for radiographic testing of metal castings. Definitions of terms relating to wrought iron, to methods of testing, to metallography, and to specific gravity are also included. New standard specifications have been adopted this year for steel tie plates, iron and steel chain, gray-iron castings for valves, seamless copper tubing, bronze and hard-drawn copper trolley wire, several specifications for galvanized wire and wire products, and specifications for zinc (hot-galvanized) coatings on structural-steel shapes and plates. Included in addition to these specifications are new standard methods of sampling rolled and forged steel products

for check analysis, test methods for galvanized wire and wire products, and a test for change of resistance with temperature of electrical heating materials. Standard specifications for open-hearth steel rails, concrete reinforcement bars, steel pipe and boiler tubes, hot-rolled bar steels and cold-finished shafting, malleable castings, and wrought-iron bars, plates, and pipe that were revised during the year have also been included.

Part II—Non-Metallic Materials

The 251 standards in Part II cover the following miscellaneous groups of non-metallic materials and products: cement, lime, gypsum, concrete and concrete aggregates, brick and refractories, pipe and drain tile, hollow building tile, paints, pigments, shellacs, varnishes, petroleum products and lubricants, bituminous and non-bituminous road materials, coal and coke, timber and timber preservatives, waterproofing and roofing materials, insulating materials and rubber products, textile materials, and thermometers for general use. Included in this volume are new standards adopted this year comprising specifications for paving and building brick; sand-lime brick, wall, floor and partition hollow clay tile; Keene's cement and gypsum plasters; gravel for bituminous concrete; several specifications for tar cements for road application; tolerances for tire-cord fabrics, and fabrics other than cord fabrics; methods of testing concrete aggregates; gypsum and gypsum products; analysis for color of paints; tests for sulphur in gasoline, melting point of petrolatum, autogenous ignition temperatures of petroleum products; mechanical analysis of coal; and test methods for electrical porcelain. The specifications for portland cement revised to include higher tensile-strength requirements and the methods of testing cement changed by the inclusion of tolerances on weights and dimensions of apparatus are also included. Of particular interest are the revised standard specifications for structural wood, joist and planks, beams and stringers, posts and timbers.

Tentative Standards, 1930

The book of A.S.T.M. "Tentative Standards," an annual publication, contains 155 tentative specifications, methods of test, definitions of terms, and recommended practices, 28 relating to metals and 127 to non-metallic materials and products. The tentative standards are issued for one or more years with a view to obtaining criticisms. Although in the trial stage of A.S.T.M. procedure, they represent the latest thoughts of the committees on the subjects covered, and are therefore being applied in the various industries. Many of the so-called tentative standards are frequently used in conjunction with the A.S.T.M. standards.

Included in this volume are 21 new tentative standards developed this year. In the metals group are new specifications for austenitic manganese-steel castings; open-hearth iron plates; aluminum alloy (duralumin) sheet; aluminum-manganese alloy sheet; magnesium-base alloy castings; aluminum-base alloy castings and ingots; copper-base alloys in ingot form; and a method of test for thermoelectric power. A specification for high-early-strength portland cement is an important contribution to the construction field, as are also new specifications for reinforced-concrete pipe, reinforced-concrete culvert pipe, gypsum sheathing board, timber piles, and glazier's putty; test methods for natural building stone; and a flexure test for concrete. Of interest in the automotive field is the test for dilution of crankcase oil and a test for vapor pressure of natural gasoline. A test method is also included for comparing the thermal conductivities of solid electrical-insulating materials. New tentative specifications have also been developed for several lacquer solvents and diluents, namely, amyl acetate, amyl alcohol, butyl propionate, and ethyl lactate. Revisions have also been made in 25 of the tentative standards developed in former years in order to keep them abreast of current practice.

Index to Standards and Tentative Standards

An index (110 pages) of all A.S.T.M. Standards and Tentative Standards has been prepared and is being distributed without charge. The index is a compilation, under appropriate key-word subjects covered by the standards, of titles of all standards, together with volume references to the publications in which they appear, namely, Parts I and II of the 1930 "Standards," and the 1930 "Tentative Standards," and the annual Proceedings. The Index is designed to be of service to those familiar with the society's standards in locating specifications, methods of test, or definitions in the bound publications in which they appear, and as well to those interested in ascertaining if the society has issued any standards on a specific subject. The index will be found of great assistance in locating desired references.—C. B. LeP.

Industrial Evolution

Industrial Evolution. By N. S. B. Gras. Harvard University Press, Cambridge, Mass., 1930. Cloth, 5¾ × 8⅝ in., 240 pp., illus., $2.50.

Reviewed by Joseph W. Roe[1]

THE author calls this book a sketch, and says that "its brevity and lack of completeness are its merits, if it has any." It has. It outlines manufacture from the earliest stage—"usufacture" he calls it—to mass production, with chapters on the handicrafts ancient and medieval, the gilds and yeomanry, the beginnings of the centralized workshop, the industrial revolution in England and New England, and the growth of the iron and steel, shoe, chemical, and electrical industries. The swift movement in the development of these industries is shown. It took the telephone 45 years to reach 7,500,000 American homes and the electric light 36, but with the radio it took only 8 years. Professor Gras says that "the influence of America on the electrical industry of Germany has been comparable to that of Germany on the chemical industry in America." He covers the American cotton industry, but only to its spread to the Merrimac Valley, not to its spread to the South—a singular omission, as the other industries are brought to date.

A most interesting chapter traces the history of a single American factory, that of the Dennison Manufacturing Company, from 1844 to 1930. This is chosen partly as typical of a specialized industry, not associated with the great basic industries, partly because its history has been compiled as that of few others has been, and because its history covers the whole range from the early American factory to the most refined type of modern organization.

Chapters are given to recent industrial history, government aid and other factors, here and abroad, and to associations both of employers and of workmen.

The last two chapters take up the controversial questions of art in industry and large- versus small-scale industries. Professor Gras feels that beauty of output depends ultimately not on the scale of production but on the development of taste for fine products, that American taste is steadily improving, that industry will reorganize to meet it, as it has already done in the case of shoes, automobiles, etc., and that artistic small-scale handicrafts will multiply with our increasing wealth. Large-scale industries will produce utility products, and beside them will thrive small industries comparable to those of Europe.

[1] Professor of Industrial Engineering, New York University, New York, N. Y. Mem. A.S.M.E.

to meet the wants of the growing numbers of those who desire articles of individuality and beauty.

Books Received in the Library

AIRCRAFT MECHANICS' HANDBOOK. By I. W. Miller. McGraw-Hill Book Co., New York, 1931. Cloth, 5 × 7 in., 174 pp., illus., diagrams, tables, $2.

Describes the use of the hand tools used by the aircraft mechanic, and the materials and methods with which he works. The recommendations are based upon the standards and methods of the government services.

AIRPORTS: THEIR LOCATION, ADMINISTRATION, AND LEGAL BASIS. By H. V. Hubbard, M. McClintock and F. B. Williams. Harvard University Press, Cambridge, 1930. Cloth, 7 × 10 in., 190 pp., illus., charts, tables, maps, $3.50.

The three reports that constitute this study of the airport are intended to assist those faced with the necessity of deciding whether a community needs an airport, where it can best be placed, how funds for building and maintaining it may be raised, and how it should be regulated. Various leading authorities discuss these problems in the light of American cities, from the legal, financial, and city-planning points of view.

AUSGEWÄHLTE SCHWEISSKONSTRUKTIONEN. Band 2, Maschinenbau. By K. Haas. V.D.I. Verlag, Berlin, 1931. Cloth, 8 × 12 in., 97 pp., illus., diagrams, 14.50 r.m.

This atlas is a collection of photographs showing the application of welding to structures of all kinds. The present volume is concerned with welding in the construction of machinery. Ninety-seven plates show the practice of European and American manufacturers and illustrate many ways in which welding may replace riveting or casting.

LIGHT AERO ENGINES. By C. F. Caunter. Isaac Pitman & Sons, New York, 1930. Cloth, 5 × 7 in., 288 pp., illus., $3.50.

Intended to give the owner and the ground engineer the necessary information about the aircraft engines now in use, and to instruct him in overhauling and caring for them. About forty designs of engines are explained and their chief characteristics given.

LUFTBEFEUCHTUNGSANLAGEN UNTERSUCHUNGEN UND BERECHNUNGEN. By Fritz Kastner. R. Oldenbourg, Munich and Berlin, 1931. Paper, 7 × 10 in., 84 pp., illus., 6.50 r.m.

A report upon an investigation undertaken to determine accurate data as a basis for the design of air-conditioning plants. The author investigated thoroughly conditions in a large textile mill. Conditions of air flow and humidity were determined by measurement and compared with theoretical conclusions. Various methods of conditioning were compared. Directions to designers are given.

MITTEILUNGEN DER DEUTSCHEN MATERIALPRÜFUNGSANSTALTEN; SONDERHEFT 13. Julius Springer, Berlin, 1930. Paper, 9 × 12 in., 142 pp., illus., diagrams, tables, 21 r.m.

Contains twenty-six reports on investigations carried out at the Kaiser Wilhelm Institut für Metallforschung and the Staatlichen Materialprüfungsamt. These cover a wide variety of subjects, including: insect attacks on metals, the influence of pores on the strength of die castings, the improvement of alloys, recrystallization of metals, arsenic in steel, and other subjects of interest to mechanical engineers and metallurgists.

THE MODERN STEAM TURBINE. By E. A. Kraft, V.D.I. Verlag Berlin, 1931. Cloth, 8 × 10 in., 201 pp., illus., 20 r.m.

Dr. Kraft is not concerned with the theory or general design of steam turbines; instead he gives a descriptive critical account of modern trends in turbine construction, illustrated by many examples of actual turbines in which they are applied. This English edition of the views of an eminent expert will be welcomed by many engineers.

NON-METALLIC INCLUSIONS IN IRON AND STEEL. By Carl Benedicks and Helge Löfquist. John Wiley & Sons, New York, 1931. Cloth, 6 × 10 in., 311 pp., illus., diagrams, $8.

The authors have reviewed exhaustively the existing literature upon the slag problem, up to the beginning of 1928, and have studied it in detail, so that the book is a valuable presentation of our knowledge of slags, of the conditions that cause them to be dispersed through a metal, and of their effect upon its properties. Possible methods of reducing slag content are also discussed. A very valuable bibliography is included.

ORGANIZATION ENGINEERING. By Henry Dennison. McGraw-Hill Book Co., New York, 1931. Cloth, 5 × 8 in., 204 pp., 8 × 5 in., $2.

This book discusses the problems of group life and action, and points out some of the conditions that are necessary for effective work by organizations. The characteristics of human nature which the manager must understand are surveyed, methods for guiding and increasing joint productivity are considered, and the principles of organization structure are set forth.

PROPERTIES AND MECHANICS OF MATERIALS. By P. G. Laurson and W. J. Cox. John Wiley & Sons, New York. Cloth, 6 × 9 in., 353 pp., illus., diagrams, tables, $3.75.

This textbook is intended to combine the study of engineering materials and of the mechanics of materials in a single course. The authors have endeavored to give the student a thorough knowledge of the fundamentals within the time usually allotted to these subjects, so that he will be able later to approach specialized cases confidently in practical work.

REGLER FÜR DRÜCK UND MENGE. By Guido Wünsch. R. Oldenbourg, Munich and Berlin, 1930. Cloth, 6 × 9 in., diagrams, 13 r.m.

A concise book on industrial devices for controlling pressure and volume, by the designer for the Askania Werke, Berlin. The author writes for the operating engineer, to whom he gives an account of the principles and mode of action of automatic control devices and discusses the conditions under which they are effective. Information upon design is given, and there are numerous examples of the practical application of regulators to many operations.

RICHTLINIEN FÜR GESCHWEISSTE GASROHRLEITUNGEN VON MEHR ALS 200 MM. DURCHMESSER UND MEHR ALS 1 ATÜ BETRIEBSDRUCK. V.D.I. Verlag, Berlin, 1930. Paper, 6 × 8 in., 10 pp.

Specifications for welding gas mains, approved by the Standards Committee of the Society of German Engineers.

REPORTS AND PAPERS, 1930. The American Society of Mechanical Engineers Research Committees. A.S.M.E., New York, 1931. Bound, 8 × 11 in., various pagings, illus., diagrams, tables, $4.

A record of the latest achievements of the various research committees of the Society. The topics discussed include antifriction bearings, boiler-metal failures, Diesel fuel oil, lubrication, management, mechanical springs, metal cutting, metal at high temperatures, thermal properties of steam, and wire rope.

These papers have appeared in the Transactions of The American Society of Mechanical Engineers and in MECHANICAL ENGINEERING. They reappear in this volume in convenient form for preservation.

STANDARD FOUR-FIGURE MATHEMATICAL TABLES. 2 vols. (1 vol. Edition A; 1 vol., Edition B). By L. M. Milne-Thomson and L. J. Comrie. Macmillan Co., London and New York, 1931. Cloth, 8 × 11 in., 245 pp. each vol., diagrams, $4.50 each vol.

This work is intended to provide a comprehensive table of the numerical values of the elementary functions that are in constant use in the applications of mathematics in physics, engineering, statistics, etc.

The tables are well printed and well arranged. A number of tables are included which are usually not readily available, such as trigonometrical functions with the argument in radians, hyperbolic functions, inverse trigonometrical and hyperbolic functions, natural logarithms and powers of e.

Each volume is convenient to handle and reasonably priced. Edition A has positive characteristics in the logarithms; edition B, negative characteristics.

SUR L'UTILISATION DE LA CHALEUR DANS LES MACHINES A FEU. By Henri B. Reitlinger. Ch. Béranger, Paris & Liége, 1930. Paper, 7 × 10 in., 254 pp., 60 fr.

An investigation of the complex phenomena involved in the operation of a thermal power plant, undertaken to develop a method by which the conditions for securing maximum efficiency of the plant, as a whole, may be determined. The author first presents the laws governing the thermostatic and thermodynamic transformations in a new form, which enables him to obtain a more complete view of the utilization of the heat than can be obtained by the usual methods. He then applies the results of the method to the solution of practical problems, and shows how this may be used in the design of power plants of various kinds.

SYMPOSIUM ON AIRCRAFT MATERIALS. American Society for Testing Materials. Philadelphia, 1930. Cloth, 6 × 9 in., 192 pp., illus., diagrams, Price not indicated.

Contains eighteen papers by various engineers discussing such matters as the metals, alloys, woods, and textiles used in constructing aircraft, aircraft finishes, the use of stampings and castings, failures of engine parts, specifications, mechanical and X-ray testing, welding procedure, and heat treatment.

DER TEMPERGUSS. By E. Schüz and R. Stotz. Julius Springer, Berlin, 1930. Bound, 6 × 9 in., 390 pp., illus., plates, diagrams, tables, 39 r.m.

A textbook and reference book for makers of malleable castings. The authors give an interesting history of the process, discuss the theoretical principles involved, and describe in detail the equipment and processes used, the layout of foundries, and the calculation of costs. The treatment is thoroughly practical. A list of European malleable foundries and a useful bibliography are included.

TURBINEN-SCHNELLÄUFERN, Theorie und Bau. By Viktor Kaplan and Alfred Lechner. R. Oldenbourg, Munich, 1931. Cloth, 7 × 10 in., illus., diagrams, 18 r.m.

This book, which is an entirely rewritten edition of Professor Kaplan's former work, "Bau der rationellen Francis Turbinen Laufraeder," contains an account of the practical and theoretical results of his many years of experimental work upon high-speed turbines, and of the development of the Kaplan turbine. The principles of runner design and methods of regulation are set forth and illustrated by actual installations. Professor Lechner presents a summary of the hydromechanical investigations that have interest to the turbine designer, and a statement of turbine theory.

VECTORIAL MECHANICS. By Louis Brand. John Wiley & Sons, New York, 1930. Cloth, 6 × 9 in., 544 pp., $5.

An introductory textbook for students of engineering and physics. Statics, kinematics, and dynamics are discussed successively, with greater fullness than necessary for the usual college course, with the object of making the book useful also as a reference book. A simple, direct exposition that meets reasonable standards of rigor has been sought.

VORLESUNGEN ÜBER MASCHINENELEMENTE, No. 5; Elemente der Kolbenmaschinen Rohrleitungen. By M. ten Bosch. Paper, 8 × 11 in., 86 pp., illus., diagrams, tables, 7 r.m.

This treatise on the elements of mechanism is modeled upon Bach's classic work, but is thoroughly modern in its presentation. It is intended for students of engineering who wish a concise, modern textbook. The present section, on piston engines and piping, completes the work.

VORTRÄGE AUS DEM GEBIETE DER AERODYNAMIK UND VERWANDTER GEBIETE (Aachen, 1929). A. Gilles, L. Hopf, and Th. v. Kármán, editors. Julius Springer, Berlin, 1930. Bound, 6 × 9 in., 221 pp., illus., diagrams, 20 r.m.

A collection of discourses by well-known investigators in the field of aerodynamics, describing their recent work. The addresses treat of a variety of topics of interest to students of aerodynamic theory and designers of aircraft. They were delivered at the reopening of the enlarged Aerodynamic Institute at Aachen in 1929.

WERKSTOFFE PHYSIKALISCHE EIGENSCHAFTEN UND KORROSION. By Erich Rabald. Otto Spamer, Leipzig, 1931. 2 vols. Paper and cloth, 7 × 10 in., illus., tables, paper, 128 r.m., bound, 135 r.m.

A remarkable summary of the literature on corrosion of the metals and non-metals. The author has examined the material published between 1897 and 1929, and gives the salient facts in brief form, with references to sources. The bibliography contains about ten thousand items. An index by attacking agents is included, enabling the proper materials for any purpose to be found quickly.

The work will be indispensable to students of corrosion and most valuable to designers of plants which use chemicals.

WOOD, LUMBER, AND TIMBERS. By Phillips A. Hayward. (Chandler Cyclopedia for the scientific selection, purchase, and use of commodities, v. 1.) Chandler Cyclopedia, N. Y., 1930. Fabrikoid, 8 × 11 in., 521 pp., illus., tables, maps, $10.

Users of wood will find here a large amount of practical assistance in selecting the best wood for any purpose and in buying it to the best advantage. The book brings together in convenient form the data developed by various research institutions and trade associations concerning the physical and mechanical properties of wood, the methods of manufacturing and grading lumber, the industrial uses of the various species of wood, and other matters of interest to consumers. References for further information are frequent throughout the book.

ZEPPELIN, a Biography. By Margaret Goldsmith. William Morrow & Co., New York, 1931. Cloth, 6 × 9 in., 278 pp., portraits, $3.50.

This biography gives a readable, popular account of the great inventor's career from birth to death. His exploits in aviation are discussed at length, but little is included upon the engineering aspects of his work.

VERTRIEBSHANDBUCH FÜR INDUSTRIELLE BETRIEBE. By J. A. Bader and F. Zeidler. V.D.I. Verlag, Berlin, 1931. Cloth, 6 × 9 in., 326 pp., illus., diagrams, charts, tables, 17.50 r.m.

A handbook on marketing machinery, issued by the sales engineering division of the Society of German Engineers. Discusses such questions as market analysis, statistics, sales organization, sales costs, advertising, sales promotion, packing, and delivery.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following page appear in the current issues of Applied Mechanics, Oil and Gas Power, and Fuels and Steam Power sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced, when completed, in later issues of "Mechanical Engineering."

APPLIED MECHANICS PAPERS

THE STRESSES IN ROTATING DISKS. By T. H. Frost and K. F. Whitcomb. [Paper No. APM-53-1]

This paper comprises the results of a photoelastic investigation, sponsored by The Norton Company, of the stresses in rotating disks. The classical theory of Chree with a few additions is presented, and the results of the experimental determinations are compared with the theory as well as actual breakages of vitrified wheels.

VIBRATIONS OF RAILWAY BRIDGES. By J. N. Goodier. [Paper No. APM-53-2]

The paper contains a discussion of the nature of the approximately resonant vibrations of bridges due to the pulsating forces generated by unbalanced drivers, the influence of the motion of the train, and possible action of the springs; a group of proposed approximate formulas for predicting the natural frequencies of bridges, whether unloaded or supporting trains; a description of the methods of measuring natural frequencies; a list of the sources of damping; a theoretical demonstration of the effects of a small amount of distributed damping in restraining the forced vibration, and an appendix in which the frequency formulas are derived.

PLASTIC TORSION. By A. Nadai. [Paper No. APM-53-3]

Among the locally varying distributions of stress with partial yielding, that of a twisted bar is treated, for which the transition from a state of equilibrium with purely elastic deformations to one with plastic deformations was investigated. An analogy described on an earlier occasion was utilized to determine by an experimental method the distribution of stress in the twisted bar. This distribution of stress was compared with the position of the thin layers of slip observed in the etched cross-sections of twisted steel bars.

FLOW OF GASES AT A RATE EXCEEDING THE ACOUSTIC VELOCITY. By O. G. Tietjens. [Paper No. APM-53-4]

This paper deals with the flow of gases at high velocities, that is, at velocities exceeding the velocity of sound in the gas under the existing conditions of temperature and pressure. The discussion starts with the development of the fundamental equations of flow and shows why the acoustic velocity assumes such critical importance. In particular, the flow of gas through a De Laval nozzle is considered, the natural assumption of adiabatic flow being made. The so-called compression shock is discussed and the conditions under which these shocks occur, their connection with the acoustic velocity, and their effect on the flow through the nozzle, are pointed out.

FUELS AND STEAM POWER PAPERS

STOKERS AND FURNACES FOR NEW ENGLAND FUELS. By R. A. Foresman and Donald J. Mosshart. [Paper No. FSP-53-1]

In this paper the authors describe and analyze some of the troubles encountered in stoker installations and discuss the principal factors to be considered in making a successful stoker installation. The discussion is limited to those problems found in New England where the fuel used creates problems peculiarly local. The principal fuel of New England is a semi-bituminous coal, known to the trade as Pocahontas and New River coal. Among the points discussed are selection of type and size of stoker, preheated air, furnace volume, furnace walls, ash-disposal apparatus, waste fuel, operating methods, banking, boiler operation, and recent stoker installations. Many of the points discussed receive recognition in the majority of plants, but relatively few plants recognize them all. The authors bring these practical matters together in one group.

SOOT PARTICLES IN NEW YORK CITY AIR. By E. E. Free. [Paper No. FSP-53-2]

In this paper the author tells of the methods used and the results obtained in a series of counts of soot and dust particles in the air of New York City. The counts were made by an impact dust counter. Two variables affect the results. One is the wind and the second the degree of clumping or flocculation of the soot particles in the air. The number of soot particles counted showed a high degree of correlation with wind direction. Nothing was discovered to show the causes for clumping of the soot particles.

BOILER SETTINGS FOR BURNING REFUSE WOOD. By C. S. Gladden. [Paper No. FSP-53-3]

This paper includes a discussion of: (1) Some recent developments in the design of boiler furnaces for burning green or wet refuse wood; (2) the experiences influencing the development of furnaces for burning dry refuse wood; and (3) factors influencing the design of wood-burning furnaces.

COMPARATIVE PERFORMANCE OF A PULVERIZED-COAL-FIRED BOILER USING BIN SYSTEM AND UNIT SYSTEM OF FIRING. By A. E. Grunert. [Paper No. FSP-53-4]

An experimental program had for its object the comparative performance of a modern boiler unit served first with the bin system of pulverized-coal firing and later with the unit system of firing, thus making possible comparisons on a common basis. The paper deals with specific types of equipment, certain types of coal, and operating conditions, influenced somewhat by local conditions. The operation of these two systems is compared in three ways—first, on an evaporative-test basis; second, on a basis of actual overall performance; and, third, on an operating-cost basis. A record of the pertinent experiences with both systems is given. Owing to the specific nature of the program no general conclusions are given, and there is no intention to contribute to the controversial phase of the matter.

RECOVERY OF FLY ASH FROM PULVERIZED-FUEL STACKS BY USE OF STACK SPRAYS. By J. W. Mackenzie. [Paper No. FSP-53-5]

One of the first central stations designed for the unit system of pulverized-fuel operation with preheated air encountered difficulty due to fly ash from the stack. The extent of the trouble was determined by locating boards freshly painted with white paint throughout the district. A water spray installed in the stack stopped all complaints, but necessitated lining the stack with acid-resisting material. Tests show that with the spray in operation about 5 per cent of the coal is discharged as solids from the stack, and that the spray takes out about 35 per cent of the solids coming to the stack. A detailed description is included of the equipment and methods used for collecting representative samples of the solids in the flue gases.

This paper outlines the influences which led the Consumers Power Company to adopt a spray system in the stacks of its pulverized-fuel-fired plants as a means of combating the fly-ash problem, and shows the results which operation and tests have revealed as to the effectiveness of the system.

TESTS OF THE RESISTANCE TO REPEATED PRESSURE OF FORGED, RIVETED, AND WELDED BOILER SHELLS. By H. F. Moore. [Paper No. FSP-53-6]

Data regarding the performance of welded joints in resisting repeated stresses are very important in any consideration of the adoption of welded construction for power boilers, and it is the object of this paper to present such data. Comparative tests were made on (1) a standard A.S.M.E. riveted drum, (2) a manganese-

steel riveted drum, (3) a forged seamless-steel shell, (4) two forge-and-hammer-welded shells, and (5) eight fusion-welded (metallic-arc) shells, each drum or shell being subjected to applications of pressure well above the allowable working pressure.

The results indicate that under repeated stress properly made welded joints are stronger than the plates themselves when weakened by "stress raisers" such as small holes or surface defects. The tests also give useful data on the strength of drum heads when subjected to intermittent pressures.

THE DRY QUENCHING OF COKE. By William O. Renkin. [Paper No. FSP-53-7]

This paper describes the process of dry quenching or cooling of coke with automatically formed inert gases, the sensible heat in the glowing coke being used to heat the cooling gases, which in turn pass through boilers, producing steam at useful pressure and economic cost without the consumption of any other fuel. Formulas, curves, and data regarding heat available and method of calculation are given, together with descriptions of installations and illustrations of plants in operation.

A detailed economic study is given which shows the savings to be expected and the approximate cost of a dry-quencher plant to cool 1500 net tons of coke per day; and composite charts giving actual operating records as well as output data and the cost of power for one plant by months for the year 1929 are included.

Analyses of coal and coke are given which show conclusively that dry-quenched coke carries less dust than wet-quenched coke.

Data giving actual results obtained by using dry-quenched coke in blast furnaces, and the advantages of substituting dry-quenched coke fines for high-priced bituminous gas coal in gas producers, are discussed in considerable detail.

A dry-quencher plant at a power station in Flint, Mich., the latest to be installed, is described in some detail and the principal technical data given.

THE PERFORMANCE RATING OF STEAM-GENERATING EQUIPMENT. By H. L. Solberg. [Paper No. FSP-53-8]

The demands for high capacity, high efficiency, and flexibility have resulted in the development of modern stokers and pulverized-coal burners, adequate furnaces with steam- and water-cooled walls, air heaters, steel-tube economizers, etc., and have completely changed the equipment which was used for steam generation ten years ago. Consequently the author believes it is time that the methods of expressing the performance of such equipment should be revised to conform with new conditions. Considering the problem of steam generation from the viewpoint of the functional purpose of the equipment, it appears to the author that the logical method of expressing the performance of such equipment should be on the basis of the total heat absorbed by all water- and steam-cooled surfaces per unit of time, such a method being general and applicable to all types of steam-generating equipment, and expressing the performance, not in terms of arbitrary dimensions, but of actual results produced.

OIL AND GAS POWER PAPERS

THE LORENZEN GAS TURBINE AND SUPERCHARGER FOR GASOLINE AND DIESEL ENGINES. By Christian Lorenzen. [Paper No. OGP-53-1]

In this paper the author gives particulars regarding the design and construction of a gas turbine having a rotor with hollow blades which are cooled by air circulated through them under pressure. Present and future possible applications of the turbine are also discussed.

A SIMPLE METHOD FOR THE CALCULATION OF NATURAL FREQUENCIES OF TORSIONAL VIBRATION. By Frederic P. Porter. [Paper No. OGP-53-2]

The calculation of the torsional-vibration characteristics of the shafting of reciprocating-engine installations is generally considered a laborious undertaking. This paper presents a method for calculating the natural frequencies of the shafting that is relatively simple in its application and yet retains the accuracy of the longer methods. This simplification is obtained by the proper choice of the equivalent system for mathematical treatment and by the use of tables and charts. The accuracy of the results has been compared with that of the results of other investigators.

THE DIESEL-ENGINE TRACTOR AND EXCAVATOR. By C. G. A. Rosen. [Paper No. OGP-53-3]

Special emphasis is given in this paper to the combustion process for Diesel-tractor service. A variety of fuel systems were installed and tested in a rugged engine of flexible design. General results of the tests are given. Accessories are considered extremely important in tractor service, and the author discusses air cleaners, oil filters, and engine starters. The problems discussed can be applied to other traction equipment, including excavators. Reliability at all loads and speeds within the engine operating range is paramount, and maintenance costs must be kept low.

NOTE: Those who have not registered in the A.S.M.E. Applied Mechanics, Oil and Gas Power, and Fuels and Steam Power Divisions whose papers are abstracted on this and the previous page, and who desire copies of any of these papers, may obtain them by using the form given below.

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AERODYNAMICS

Turbulence. Mechanical Similitude and Turbulence, T. von Kármán. Nat. Advisory Committee Aeronautics—Tech. Memo., no. 611, Mar. 1931, 19 pp., 5 figs. Mathematical investigation of hydrodynamic phenomena based on similitude of oscillatory motion irrespective of location of point in whose vicinity oscillation is examined; Prandtl's theory of "mixing length"; flow between parallel walls; resistance law; roughness. From Nachrichten bon der Gesellschaft der Wissenschaften zu Goettingen, 1930.

AIR BRAKES

Design. Eine neue Druckluftbremse fuer Gueterzuege Personen und Schnellzuege (Novel Type of Compressed-Air Brake for Freight, Passenger, and Express Trains), W. Hildebrand. Glasers Annalen, vol. 54, no. 5, Mar. 1, 1931, pp. 122–128, 7 figs. Describes new automatic brake showing many advantages over standard types and especially advantageous over long inclines.

AIR PREHEATERS

Leakage Problem. Zur Dichtigkeitsfrage der Luftvorwaermer (Problem of Tightness of Air Preheaters), W. Gumz. Waerme, vol. 54, no. 9, Feb. 28, 1931, pp. 158–159. Effect of leakiness; requirements of air preheaters with regard to tightness; testing of leakage resistance.

AIRPLANE ENGINES

Diesel. Jalbert Heavy Oil Engine Using Carburetor and Pre-Mixing Cylinder Under Construction for the French Air Service, W. F. Bradley. Automotive Industries, vol. 64, no. 14, Apr. 4, 1931, pp. 548–549, 3 figs. Design of 6-cylinder in-line water-cooled engine of 4.92 by 7.09-in. bore and stroke, and developing 100 hp. at 1930 r.p.m.; by reason of small lift and quick return of automatic valve, higher engine speeds are possible than with usual type of pump; consumption of gas oil, 0.375 lb. per hp-hr.

AIRPLANES

Aileron Design. Effect of Variation of Chord and Span of Ailerons on Hinge Moments at Several Angles of Pitch, B. H. Monish. Nat. Advisory Committee for Aeronautics—Report, no. 370, 1930, 15 pp., 30 figs. Investigation of hinge moments of ailerons of various chords and spans on two airfoils having Clark Y and U.S.A. 27 wing sections in 10-ft. tunnel of Bureau of Standards on models of 60-in. span and 10-in. chord.

Design. Les tendances actuelles de la technique aéronautique (Present Tendencies of Airplane Design), A. Verdurand. Technique Moderne, vol. 23, no. 5, Mar. 1, 1931, pp. 151–159, 12 figs. Comparison of principal outstanding designs with particular regard to large plane; relative advantages of cantilever and semi-cantilever design, metal or wood construction, etc.

Long-Distance. The Blériot 110 Airplane (French) A Long-Distance High-Wing Monoplane, P. Léglise. Nat. Advisory Committee for Aeronautics—Cir., no. 138, Mar. 1931, 9 pp., 47 figs. Design and performance data of high-wing monoplane of wood construction designed by Zappata; span 86.94 ft.; empty 5291.09 lb.; total weight 16,093.73 lb.; wing loading 18.43 lb./sq. ft.; engine is direct-drive 600 hp. Hispano-Suiza. Translation of article in Aeronautique, Dec. 1930.

Passenger. The Wibault 280 T. 10 Commercial Airplane (French). A. Frachet. Nat. Advisory Committee for Aeronautics—Aircraft Cir., no. 140, Mar. 1931, 5 pp., 8 figs. Design and specifications of all-metal, cantilever, low-wing monoplane and equipped with three air-cooled Hispano-Wright radial engines with total power of 936 hp.; span, 74.15 ft.; weight empty, 7462.64 lb.; full load, 12,279.73 lb.; wing loading, 17.77 lb./sq. ft.; power loading, 12.94 lb. hp.; speed at sea level, 125.54 mi. hr.

Performance Calculation. Sur les plus grandes distances franchissables en avion (Maximum Distances Negotiable by Airplane), G. A. Mokrzycki. Aerophile, vol. 38, no. 11, Feb. 15, 1931, pp. 50–51, 1 fig. Application of formulas for calculating range of airplane as function of useful load, total load including fuel, and net weight of plane.

Performance Testing. Maneuverability Investigation of the F6C-3 Airplane With Special Flight Instruments, C. H. Dearborn and H. W. Kirschbaum. Nat. Advisory Committee for Aeronautics—Report, no. 369, 1930, 21 pp., 23 figs. Air speed, angular velocity, linear acceleration, and position of control surfaces were measured by instruments in airplane during loops, push-downs, pull-outs from dives, pull-ups from level flight, barrel rolls, and spins; results are given in curves showing variation of measured quantities with respect to time, and maximum values are tabulated.

Stress Analysis. Optico-Photographic Measurements of Airplane Deformations, H. G. Kuessner. Nat. Advisory Committee for Aeronautics—Tech. Memo., no. 610, Mar. 1931, 16 pp., 30 figs. Deformation of aircraft wings measured by photographically recording series of bright shots on moving paper band sensitive to light; design and operation of opticograph developed by static division of DVL (German Experimental Institute for Aeronautics).

ALLOY STEEL

Machining. The Machining of Stainless and Heat-resisting Steels. Machy. (Lond.), vol. 37, no. 963, Mar. 26, 1931, pp. 843–844. Suggestions for proper machining of alloy steels with particular regard to avoiding of work hardening; data on tapping operations and drilling speeds; importance of smooth surface.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Brass. See BRASS.

Copper. See COPPER ALLOYS.

Zinc. See ZINC ALLOYS.

ALUMINUM

Electric Welding. Arc Welding Aluminum, G. T. Kerr. West. Machy. World, vol. 2, no. 2, Feb. 1931, p. 70. Dunlap, of Aluminum Co. of America, has developed flux which has made it possible to successfully weld aluminum and its alloys with metallic arc; Hall-Scott Motor Car Co., in Berkeley, is suing this welding rod for correcting certain small defects and experimental work in connection with manufacture of motors. Before Am. Soc. Steel Treating and Am. Welding Soc.

Sheets—Drawing. Testing Drawing Qualities of Aluminum Sheets, R. J. Anderson. Machy. (N. Y.), vol. 37, no. 7, Mar. 1931, pp. 494–495, 2 figs. Application of cupping tests and interpretation of results; design of punch and die used in cupping test machine; table gives relation between cupping values and scleroscope hardness for sheet from 10 to 30 B. and S. gage.

ALUMINUM ALLOYS

Aluminum-Copper. Some Properties of Silicon-"Aluminium-Bronzes," L. J. Brice. Inst. Metals—Advance Paper, no. 547, Mar. 11–12, 1931, 18 pp., 15 figs. Results of detailed study of Brinell hardness, mechanical properties, and microstructure of three typical aluminum-copper alloys, containing, respectively, 5.0, 7.25, and 10.0 per cent aluminum, with addition to each of up to 5.0 per cent silicon; alloys have been examined in chill-cast condition, and also after subjection to mechanical and heat treatment.

Treatment. Aluminum Alloys and Their Treatment, J. W. Urquhart. Heat Treating and Forging, vol. 17, nos. 2 and 3, Feb. 1931, pp. 155–156 and Mar., pp. 260–262. Importance and application of age hardening; constitutional changes during treatment; comparison of physical properties of Y alloys with duraluminum; forging and stamping temperatures; RR 50 alloy.

AUTOMOBILE ENGINES

Krupp. Die Hauptmerkmale des 100 PS-Sechszylinder - Krupp - Bluehring - Motors fuer Leichtoel- und Schweroelbetrieb (Characteristics of 100-Hp. 6-Cylinder Krupp. Blow-Ring Engine for Light and Heavy Oil Fuels). Kruppsche Monatshefte, vol. 12, Feb. 1931, pp. 21–25, 6 figs. Design and operating principles of engine of 100 by 160-mm. bore and stroke with electric spark ignition and arrangement permitting switching over from gasoline to heavy oil without stopping engine.

AUTOMOBILES

Brake Linings. Friction Fabrics—From Raw

Asbestos to the Finished Product. Commercial Motor, vol. 53, no. 1356, Mar. 10, 1931, pp. 118–121, 8 figs. Production methods and equipment involved in manufacture of facings for clutches and brakes at plant of British Belting and Asbestos Co.

Front-Wheel Drive. Une solution de l'avenir les roues avant motrices (Solution of the Future: Front-Wheel Drives), A. Boudineau. Revue Industrielle, vol. 61, no. 2260, Mar. 1931, pp. 160–164, 14 figs. Design and operation of principal types of universal joints with particular regard to those with constant angular velocity, including Cromption, Retel, Mechanic, Hooke, Weiss, Parville and Tracta. See Engineering Index, 1930, p. 149.

Springs. Ein neues Federblattprofil (New Leaf-Spring Profile). Kruppsche Monatshefte, vol. 12, Jan. 1931, pp. 7–9, 4 figs. Advantages of leaf-spring profile in production by Fried. Krupp Aktiengesellschaft; springs can be loaded considerably in excess of calculated maximum load without permanent deformation; improved utilization of material combined with space for retaining lubricant.

Steering Gears. Steering Design, R. Dean-Averns. Automobile Engr., vol. 21, no. 278, Mar. 1931, pp. 109–113, 13 figs. Problems of steering-system design in relation to general performance; influence of front axle, suspension, front brakes, or frame stiffness; diagrams and formulas for calculating turning radius with particular regard to multi-axle vehicles or tractor-trailer combinations; spring deflection and steering interference.

B

BEARINGS

Roller. See RAILROAD ROLLING STOCK.

BOILERS

Control. Ermittelung des wirtschaftlichen Luftueberschusses (Determination of Economic Excess Air), H. Schlicke. Waerme, vol. 54, no. 7, Feb. 14, 1931, pp. 113–115, 3 figs. Importance of accurate determination of excess air; flue-gas and carbon-monoxide losses determine waste-gas loss; importance of recording exhaust-gas temperature.

Corrosion Prevention. Die Korrosion in Schiffskesseln und ihre Bekaempfung durch Speiswasserpflege (Marine-Boiler Corrosion), H. Janssen. Schiffbau, vol. 32, no. 3, Feb. 1, 1931, p. 66; see also brief translated abstract in Mar. Engr. and Motorship Bldr., vol. 54, no. 642, Mar. 1931, pp. 116–117. Calcium and magnesium salts in feedwater give rise to formation of scale; investigations showed presence of hydrochloric acid, which must have been produced by heat from magnesium chloride in salt water; sodium hydroxide is introduced in German naval practice into boilers as foam and has proved very successful in acid, priming, and scale avoidance.

Design. Symmetrische Rauchgasfuehrung bei Dampfkesselanlagen (Symmetric Flue-Gas Ducts in Boiler Plants), H. Schlicke. Brennstoff und Waermewirtschaft, vol. 13, no. 2, Feb. 1931, pp. 23–26, 6 figs. Asymmetric arrangement of parallel-connected flue-gas ducts causes irregular performance and irregular burning-off of refractory walls; means for obtaining symmetric conduction of flue gas and air supply.

Furnaces—Design. Nouvelle théorie du tirage naturel prévision et fonctionnement d'une cheminée accouplée a un circuit de chauffage (New Theorie of Natural Draft Design and Functioning of Chimney in Connection With Heating Surface), M. Veron. Societe des Ingenieurs Civils de France—Memoires, vol. 83, no. 9–10, Sept.-Oct. 1930, pp. 747–819, 12 figs. General laws covering steady flow of fluids and fundamental principles of draft; calculation of chimney providing economic passage of given amount of gas through heating circuit and chimney unit; interference of atmospheric conditions with draft and critical study of various draft formulas.

Locomotive. See LOCOMOTIVES, Boilers.

Natural-Gas. Comparison of Natural Gas Fuels—II, P. B. Place. Power Plant Eng., vol. 35, no. 8, Apr. 15, 1931, pp. 447–449, 2 figs. Significance of high and low heating values; determination of heating valve by means of chart; analysis of typical natural-gas samples; factors affecting heat values.

Operation. Erfahrungen aus dem Kesselbetrieb im Grosskraftwerk Boehlen (Experiences in Operation of Super Power Plant Boehlen), Zeuner. V.D.I. Zeit., vol. 75, no. 11, Mar. 14, 1931, pp. 309–316, 28 figs. Report on operating experiences in boiler plant of 13,000 sq. m. of heating surface fired with pulverized lignite, with particular regard to problems of slag and cleaning of boiler furnace and boiler; arrangement of additional burners in corner and complete lining of furnace with cooling tube increased steam output of individual boiler to 160 tons per hr. and total steam output of plant from 700 to 1200 tons per hr.

Ueber die Auswirkung von Betriebsunterbrechungen auf die Waermeausnuetzung in Kesselanlagen (Effect of Plant Interruptions on Heat Utilization in Boiler Plants), W. Deinlein. Zeit. des Bayerische Revisions-Vereins, vol. 35, nos. 5 and 6, Mar. 15, 1931, pp. 39–42, and Mar. 31, pp. 53–55, 5 figs. Method is shown by means of which influence of plant interruptions can be calculated graphically; examples are given.

Priming. Das Mitreissen von Wasser aus dem Dampfkessel (Priming of Boilers), H. Vorkauf. Forschungsheft, vol. 2, no. 341, Feb. 1931, 22 pp., 45 figs. Results of tests show relation of moisture content of steam to boiler load, steam-space conditions remaining unaltered; after determination of permissible load in relation to moisture, relation between steaming surface, steam space, and evaporation with start of priming is investigated; influence of nature and concentration of brines, such as occur in boiler practice; results are expressed in empiric formulas.

Repairs by Welding. Dampfkesselreparaturen durch Anwendung der zugelassenen Schweissverfahren (Boiler Repairs by Use of Permissible Welding Processes), F. A. Birke. Waerme, vol. 54, no. 10, Mar. 7, 1931, pp. 175–179, 13 figs. Welding processes employed in boiler repair and specifications involved; direct and indirect application of welding to inclined-tube boilers; damages to fire-tube boilers and their elimination by welding; small boilers in which original riveting has been replaced completely by welding.

Tubes—Testing. Ueber ein magnetisches Verfahren zur Pruefung von Kesselrohren (Magnetic Method of Testing Boiler Tubes), F. Wever and A. Otto. Mitteilungen aus dem Kaiser-Wilhelm—Institut fuer Eisenforschung zu Duesseldorf, vol. 12, no. 24, 1930, report no. 169, 1930, pp. 373–387, 48 figs. Review of research and literature; results of tests; influence of field intensity of magnetization; magnetization in low-intensity and high-intensity fields; examples of application.

Water-Tube. Schraegrohr - Steilrohrkessel (Combined Inclined Tube-Vertical Tube Boilers), H. Garbe. Archiv fuer Waermewirtschaft, vol. 12, no. 3, Mar. 1931, pp. 91–92, 2 figs. It is claimed progress in design of water-tube boilers has not kept pace with that brought about by introduction of traveling grates, stokers, and pulverized-coal firing; it is shown how parts of inclined-tube and vertical-tube boilers can be combined in such manner as to increase circulation of boiler water in given direction, thereby increasing reliability and efficiency of boiler.

Waste-Heat. Waste Heat Boilers With Horizontal Settings, E. S. Davies. Gas World, vol. 94, no. 2423, Jan. 10, 1931, pp. 32–34, 1 fig.; see also correspondence in Gas Jl., vol. 193, no. 3529, Jan. 7, 1931, pp. 26–27. Installation at Stretford, introduced by W. M. Carr in 1925; advantages of Spencer Bonecourt Kirke fire tube boilers; test results and waste-heat recovery. Before Manchester Junior Gas Assn.

BOLTS AND NUTS

Heat Treatment. Improved Equipment Facilitates Heat Treatment of Bolts, A. H. Allen. Steel, vol. 88, no. 9, Feb. 26, 1931, pp. 31–34, 6 figs. Continuous and practically automatic 150-kw. electric furnace provides uniform and precise heat treatment of bolts in larger sizes at Lamson and Sessions Co., Cleveland.

BORING MACHINES

Crankcase. Die Tieflochbohrmaschine—ein Spezialbohrwerk fuer Kurbelgehaeuse (Deep-Hole Boring Machines—Special Machine for Crankcases), K. Seitter. Werkstattstechnik, vol. 25, no. 6, Mar. 15, 1931, pp. 163–165, 16 figs. Operation and design of boring machine for machining of 10 main bearings of 8-cylinder engine.

BRASS

Plasticity at High Temperatures. Plasticity of Copper-Zinc Alloys at Elevated Temperatures, A. Morris. Am. Inst. Min. and Met. Engrs.—Tech. Pub., no. 390, Feb. 1931, 9 pp., 4 figs. Drop hammer test on brasses ranging upward from 62 per cent copper; alpha-brasses that have been heated so as to develop large grain are more liable to crack than samples of same alloy not so overheated; method of calculating average resistance of samples to blow; comparison of calculated resistances of lead, tin, aluminum, and zinc at room temperature with plastic flow points, as determined by ordinary tests.

BRAZING

Multiple-Joint. Multiple-Joint Brazing in Hydrogen Atmosphere, H. M. Webber. Am. Mach., vol. 73, no. 18, Oct. 30, 1930, pp. 697–698, 2 figs. Application and procedure for copper brazing process for fabricating steel parts in furnaces with controlled reducing atmospheres, developed at General Electric Company's laboratories; four effects take place to impart strength to copper-brazed joint, i.e., alloying of iron with copper, penetration of copper along grain boundaries of steel, and grain growth across joint; data on physical properties of joints.

C

CABLEWAYS

Mechanics of. The Mechanics of Aerial Ropeways, G. Brillo. Min. Mag., vol. 44, nos. 1 and 2, Jan. 1931, pp. 18–24 and Feb., pp. 81–88, 11 figs. Jan.: Historical note and general features; ropes; trestles; intermediate anchorage and stretching devices; stations; carriers; grippers; locking frames; mono-cable plant. Feb.: Aerial ropeway calculation; elements needed for calculations and design; formulas and their application.

CARS

Couplings. Baltimore and Ohio Tests Coupler Equipment. Ry. Mech. Engr., vol. 105, no. 3, Mar. 1931, pp. 126–128, 7 figs. Report of progress made in development of automatic "tightlock" car coupler for passenger-train service in which steam, air, and electric train-line connections have been incorporated.

Retarders. A New Rail Brake. Engineer, vol. 151, no. 3924, Mar. 27, 1931, p. 346, 2 figs. Latest development in hump-yard operation is eddy-current brake made by Westinghouse Brake and Saxby Signal Co.; retarder is claimed to possess number of important advantages over those depending purely on mechanical friction.

CASE HARDENING

Modern Practice. Modern Case Hardening Practice, F. W. Rowe. West Scotland Iron and Steel Inst.—Jl., vol. 38, pt. 3, Dec. 1930, pp. 27–34 and (discussion) 34–38. Choice of steel for case hardening; abnormality in case-hardening steels; nickel case-hardening steels; furnaces for case hardening; carburizing compounds; carburizing practice; heat treatment after carburizing, quenching media; nitrogen hardening.

New Carburizing Bath. New Carburizing Bath Affords Increase in Depth of Case, E. C. Moffett. Steel, vol. 88, no. 11, Mar. 12, 1931, pp. 38–40 and 42, 3 figs. Hardening steel in bath of sodium cyanide largely has been confined to case depths under 0.010 in.; limitations, however, have been removed by salt bath composed of sodium and calcium chlorides and activating ingredient. Before Am. Soc. Steel Treating.

CAST IRON

Growth. The Permanent Growth of Gray Cast Iron, W. E. Remmers. Fuels and Furnaces, vol. 9, no. 4, Apr. 1931, pp. 455–456. Phenomenon of irreversible growth of gray cast iron, results of experiments made to determine cause and condition necessary to minimize growth.

Wachtstumfestes Gusseisen fuer hoehere Temperaturen (Growth-Resisting Cast Iron for Higher Temperatures), R. Mitsche and O. von Keil. Giesserei, vol. 18, no. 10, Mar. 6, 1931, pp. 200–204, 7 figs. Views on phenomena of growth, requirements of growth-resisting cast iron; filling these requirements by means of highly silicated cast iron; growth and strength properties.

Properties. Gray Iron Possesses Valuable Engineering Properties. Foundry, vol. 59, no. 7, Apr. 1, 1931, pp. 70–73, 13 figs. Tables give data on annealing temperatures and time for removing casting strains; hardness and tensile strength of cast-iron pistons as affected by annealing temperature; effect of nickel content on electric and magnetic properties; results obtained on cast irons annealed at various temperatures; tests made by MacPherran and Fletcher.

Testing. Festikgeit und Wandstaerke bei Gusseisen (Strength and Wall Thickness of Cast Iron), A. Heller. Giesserei, vol. 18, no. 12, Mar. 20, 1931, pp. 237–241, 4 figs. Review of literature dealing with relation between strength and thickness of cast iron; comparison of experimental results shows possibility of setting up in near future diagram for strength of cast iron.

from which certain properties of cast iron can be predetermined; such a diagram is presented.

Ueber Festigkeitwerte von stehend und liegend gegossenen Ausseisen-Probestaeben (Strength Values of Vertically and Horizontally Poured Cast-Iron Test Bars), K. L. Zeyen. Giesserei, vol. 18, no. 9, Feb. 27, 1931, pp. 177–180, 2 figs. Results of comparative tests; differences between tensile strength in vicinity of gate or further removed therefrom; review of literature on top and bottom pouring of test bars; strength can be impaired by superheating of low-carbon cast iron.

COAL

Ash Problem. Das Ascheproblem (Ash Problem). Archiv fuer Waermewirtschaft, vol. 12, no. 3, Mar. 1931, pp. 65–90, numerous figs. Symposium of papers read at Fuels and Furnace Convention in Duesseldorf, Ash-Containing Fuels on Grate and Pulverized-Coal Firing, W. Schultes; Firing of Fuels Rich in Ashes, Marcord; Slag Formation on Heated Surfaces, P. Rosin; Reclamation of Coke Dust and Flue-Dust Separation, E. Rammler; Ash Removal in Boiler Room, Voight; Experiences With Hydraulic Ash Removal in Boiler Installations, O. Schoene; Removal and Use of Ashes, Gropp.

Carbonization, Low-Temperature. Low-Temperature Coal Distillation Plant at Dunston. Engineering, vol. 131, nos. 3401 and 3403, Mar. 20, 1931, pp. 386–389, and Apr. 3, 459, 25 figs. partly on supp. plate. Over two years ago low-temperature coal-distillation plant was installed at Dunston power station, Newcastle-on-Tyne; it has become evident that it would be more satisfactory to employ larger retorts; unit capable of distilling 60 tons of coal per day has been built; most important modification is that hot semi-coke, instead of being delivered to stokers or pulverizers direct, is first quenched, thus enabling 50 per cent of steam required in distillation process to be obtained very cheaply.

CONVEYORS

Monorail. Handling Assembly and Tests From an Overhead Monorail System, C. W. Preston. Iron Age, vol. 127, no. 14, Apr. 2, 1931, pp. 1084–1088, 5 figs. Layout and equipment of plant of Majestic Household Utilities Corp. manufacturers of electric refrigerators.

Operation. Synchronization of Control With Conveyor Equipment, E. M. Olin. Iron Age, vol. 127, no. 14, Apr. 2, 1931, pp. 1094–1096 and 1100, 3 figs. Factors involved in coordination of various elements of production so that finished parts, sub-assemblies and other materials meet on assembly lines when needed; data on definite savings in assembly costs obtained in partly conveyorized Westinghouse plant at Mansfield in production of heating devices including electric ranges, flat iron grills, etc.; blanks illustrate record system providing adequate control in coordinating manufacturing operation.

COPPER ALLOYS

Copper-Phosphorus. The Rolling of Alloy of Copper and Phosphorus Containing Up to 5 Per Cent of Phosphorus, L. W. Ellis. Inst. Metals—Advance Paper, no. 551, for mtg. Mar. 11–12, 1931, 6 pp. Rolling experiments on alloys of copper with 2–6 per cent phosphorus with and without addition of 5, 10, or 15 per cent, manganese or nickel.

Copper-Silicon-Zinc. A New Silicon-Zinc-Copper Alloy, E. Vaders. Metal Industry (N. Y.), vol. 29, no. 3, Mar. 1931, pp. 108–110, 14 figs. Use of silicon as deoxidizer and alloying agent; preparation of alloys; determination of solid solubility limits; mechanical and physical properties. Before Inst. Metals, indexed in Engineering Index 1930, p. 461, from Advance Paper, no. 544.

Properties. Effect of Combinations of Strain and Heat Treatment and Properties of Some Age-Hardening Copper Alloys, W. C. Ellis and E. E. Schumacher. Am. Inst. Min. and Met. Engrs.—Tech. Pub., no. 395, Feb. 1931, 13 pp., 11 figs. Investigation limited to study of alloys with content of nickel and silicon, of nickel, silicon, and cadmium, and of cobalt and silicon; effect of hard drawing subsequent to heat treatment on mechanical and electrical properties of alloys; effect of low-temperature aging on properties of heat-treated and hard-drawn alloys; effect of strain on rate of aging of quenched nickel-silicon-copper alloys.

COPPER STEEL

See STEEL, Copper.

CRANES

Motor-Truck. A New Mobile Crane. Engineer, vol. 151, no. 3925, Apr. 3, 1931, p. 383, 4 figs. Cranes made by Ransomes and Rapier are entirely self-contained units; they run on four rubber-tired wheels; power for operating cranes is derived from gasoline-electric generating unit; makers have added to their original designs super mobile crane, in which, while chassis is still able to rotate about one end, superstructure is arranged to revolve independently of chassis.

Traveling. Genormte Kleinkrananlagen (Small Standardized Crane Installations), E. Kemna. V.D.I. Zeit., vol. 75, no. 11, Mar. 14, 1931, pp. 329–331, 8 figs. Detailed description of small traveling cranes of average capacity of about 2200 lb., which are suspended from steel rail tracks.

CUPOLA PRACTICE

Corsalli Process. A New Cupola-Melted Material With a 1 Per Cent. Carbon Content, W. Gilles. Foundry Trade Jl., vol. 44, no. 757, Feb. 19, 1931, p. 144. Particulars of Corsalli process and its applications; it is now quite possible to melt material in cupola furnace with carbon content of 1.5 per cent and less, which is good for casting purposes; Corsalli method has been in use for several years in one of most important foundries of Berlin; process consists in coating each piece of coke with some sort of limey cement which prevents combustion taking place until arrival at melting zone.

CUTTING TOOLS

See TUNGSTEN CARBIDE.

D

DESUPERHEATERS

Hagan System. Pressure Reducing and De-Superheating Systems, J. E. O'Breen. Eng. and Boiler House Rev., vol. 44, no. 8, Feb. 1931, pp. 499–501, 3 figs. Outline of principal factors to be considered in selection of equipment for control of steam-pressure reduction and desuperheating; design and operating characteristics of Hagan pressure-reducing and desuperheating systems.

DIESEL-ELECTRIC POWER PLANTS

Stand-By. Large Diesel Engine for Peak Load and Stand-By Service, T. Rich. Elec. Times, vol. 79, no. 2056, Mar. 19, 1931, pp. 515–516, 1 fig. Installation at main power station of city of Hamburg, which supplies also power to electric railway and to docks; latter have perhaps largest number of electric cranes available at any port in world; unit of Hamburg is of 10,500 kw.; it is placed in same power station as series of steam turbines aggregating about 130,000 kw., largest steam units being of 34,000 kw. capacity.

DIESEL ENGINES

Automotive. A Heavy-Oil Engine for Transport Purposes. Mech. World, vol. 89, no. 2306, Mar. 13, 1931, p. 244, 2 figs. Blackstone & Co. have placed on market range of high-speed vertical crude-oil engines, comprising 2-, 4-, and 6-cylinder units of 18/20, 36/40, and 55/60 b.hp., respectively, having 4½-in. bore and 6-in. stroke, which normally run at 1000 r.p.m.; outstanding feature is patented method by which fuel is introduced into cylinder, "spring injection," which, it is claimed, gives smooth running, entirely free from knock and freedom from heavy carbon deposit, while maintaining exceptionally low fuel consumption.

A Variable-Clearance Compression-Ignition Engine Undergoes Road Tests. Diesel Power, vol. 9, no. 3, Mar. 1931, pp. 134–135, 5 figs. Design and operating features of automotive Diesel engine developed by Atlas Airplane and Engine Corp. to operate with variable compression ratio; compression diagram; scheme of compression regulation; developments carried out on White engine of 4¼ by 5¾ cylinders rated to develop 135 hp. at 2760 r.p.m., and weighting 500 lb. See editorial comment on p. 119.

Double-Acting. Diesel Engine of 22,500 b.hp. for the City of Copenhagen, Denmark. Diesel Power, vol. 9, no. 3, Mar. 1931, p. 129. Preliminary details of Diesel engine of 22,500 b.hp. to be constructed for municipal electricity works at Copenhagen, Denmark; eight double-acting two-cycle cylinders; direct-connected to a.c. generator of 15,000 kw. rating at 6000 volts.

Fuel Injection. Die Zusammenarbeit von Pumpen und Duesen bei Kompressorlosen Dieselmotoren (Cooperation of Pump and Nozzles in Compressorless Diesel Engines), P. L'Orange. V.D.I. Zeit., vol. 75, no. 11, Mar. 14, 1931, pp. 326–328, 8 figs. Investigation of effect of proper timing of injections, development of pressure rise from beginning to end of injection; analysis of pressure curve and its characteristics as determined by pump and nozzle, and pipe connections.

Effect of Orifice Length-Diameter Ratio on the Coefficient of Discharge of Fuel-Injection Nozzles, A. G. Gelalles and E. T. Marsh. Nat. Advisory Committee Aeronautics—Tech. Note, no. 369, Mar. 1931, 13 pp., 11 figs. Variation of coefficient of discharge with length-diam. ratio of orifice was determined for nozzles having single orifices 0.008 and 0.020 in. in diam.; ratios from 0.5 to 10 were investigated at injection pressures from 500 to 5000 lb. per sq. in.

Fuel Pumps for Solid-Injection Diesels. Power, vol. 73, no. 12, Mar. 24, 1931, pp. 480–483, 11 figs. Speeding up of engines has brought new problems of fuel pumping for which improved mechanisms have been evolved; design and operating features of various Diesel engine fuel pumps.

High Speed—Design. New German Semi-Diesel Engine, E. P. A. Heinze. Power, vol. 73, no. 14, Apr. 7, 1931, p. 552, 2 figs. Invention of new type of motor to work either as Diesel or semi-Diesel, in which lower compression and spark-plug ignition of latter are sole points of difference between two systems; design, construction, and operating features; advantages of type of motor is extraordinary simplicity and cheapness with which it can be produced, since expensive high-pressure pumps and finely calibrated and worked nozzles are dispensed with; principle of working applicable to four-stroke and two-stroke motors.

Marine (Busch-Sulzer). Busch-Sulzer Develops New Engines. Mar. Eng. and Shipg. Age, vol. 36, no. 4, Apr. 1931, pp. 180–181, 6 figs. Two-cycle single-acting engines in which are incorporated A.E.G.-system of mechanical injection and novel Busch-Sulzer features of design, including improved type of forged-steel piston designed to avoid stuffing boxes and packing rings for water-cooling spaces.

Starting. Increased Compression Ratio May Solve Cold Starting Problem of Compression-Ignition Engines Cold Starting, R. Matthews. Automotive Industries, vol. 64, no. 13, Mar. 28, 1931, pp. 508–511, 6 figs. Relative importance of factors controlling cold starting with particular regard to final compressions, effect of decrease in cylinder diameter; relation between compression pressure and temperature.

E

ELECTRIC FURNACES

Heat-Treating. Bright Anneals in Artificial Atmospheres, J. C. Woodson. Elec. Jl., vol. 28, no. 4, Apr. 1931, pp. 246–247, 3 figs. Possibilities of annealing in artificial atmospheres, which process is still in development stages, are not known; however, certain surface conditions can be obtained that reduce number of subsequent operations and greatly increase die life and reduce machine work; various types of electric furnaces are illustrated.

Steel-Making. Montreal Plant Produces Electric Furnace Steel in Large Quantities. Can. Machy., vol. 42, no. 5, Mar. 5, 1931, pp. 27–30, 5 figs.; see also Iron and Steel Canada, vol. 14, no. 2, Feb. 1931, pp. 30–32, 3 figs. Canadian Tube and Steel Products, Ltd., Montreal, has become independent for its steel ingot and rod requirements through installation of electric steel-melting furnaces; installation consists of two Volta furnaces of Heroult type; electrode arrangements; furnace tilting; oxidation and reduction; low voltage use; ingot stripping.

F

FANS

Propeller-Type. Further Measurements of Propeller Fan Characteristics, P. S. Ballif and H. L. Dryden. U. S. Bur. Standards—Jl. Research, vol. 6, no. 3, Mar. 1931, pp. 387–399, 12 figs. Characteristics of 4-blade propeller fan 8 ft. in diam. operating under conditions approximating those encountered in cooling towers have been determined for comparison with performance of 2-blade propeller fans, thus establishing experimentally effect of increasing number of blades.

FEEDWATER HEATING

Waste-Heat Utilization in. Die zeitgemaesse Abdampfverwertung (Exhaust-Steam Utilization), G. Spettmann. Feuerungstechnik, vol. 19, no. 2, Feb. 15, 1931, pp. 21–24, 1 fig. In treatment of feedwater it is necessary to draw upon all sources of waste heat in boiler plant, because in this way available waste heat is returned, together with feedwater, to boiler in

most rapid manner and best fuel economy is effected; water, which serves as heat carrier in thermodynamic cycle inversion of engine, effects a cycle which in modern steam-turbine plants is always closed; cycle is completed by utilizing engine condensate for boiler feed; advantages of this arrangement are set forth.

FORGE SHOPS

Practice. Etude des temps de chauffe et de refroidissement dans une forge (Study of Heating and Cooling Time in Forge Shop), G. Ivanow. Pratique des Industries Mecaniques, vol. 13, no. 11, Feb. 1931, pp. 468–469. Investigation for purpose of improving efficient operation in forge shops by determining heating and cooling period in advance; tables give data on effect of different temperatures and dimensions of forging.

Time Study in. Stueckzeitermittlung in der Freiformschmiede (Time Study in Forge Shop). Maschinenbau, vol. 10, nos. 4 and 5, Feb. 19, 1931, pp. 141–144 and Mar. 5, pp. 185–187, 16 figs. Survey of time-study method made by V.D.I. Committee for Forge Shop Practice; classification of principal types of forge-shop work; blank forms and charts illustrate methods of recording and evaluation of results.

FOUNDRY PRACTICE

Production Control. Organization and Control of Factory Production at Hans Renold Limited, T. G. Heckels. Mech. World, vol. 89, nos. 2305 and 2306, Mar. 6, 1931, pp. 217–219 and (discussion) pp. 241–242. Author describes in outline particular method of production control which is in successful operation at works of Hans Renold, Ltd.; output consists solely of driving, conveying and cutting chains, with their wheels and accessories; normal output is 200,000 ft. of chain of 150 different size of varieties, and about 2500 wheels per week. Before Instn. Production Engrs.

FUELS

Combustion. Mechanism of Combustion of Individual Particles of Solid Fuels, D. F. Smith and A. Gudmundsen. Indus. and Eng. Chem., vol. 23, no. 3, Mar. 1931, pp. 277–284, 14 figs. Effect of particle size, air velocity, temperature, and humidity on rate of burning of carbon particles has been investigated under carefully controlled conditions; method involves bringing accurately shaped and weighed spheres of carbon to known temperature in inert gas, suddenly blasting particle with very short interval, quickly quenching particle in inert gas, again weighing to determine amount of reaction, and obtaining careful record of particle surface temperature during combustion.

Low-Grade. Zuendung und Verbrennung heizwertarmer Brennstoffe (Ignition and Combustion of Fuels With Low Calorific Value), Marcard. Waerme, vol. 54, no. 12, Mar. 21, 1931, pp. 208–213, 10 figs. Exact critical data on ignition properties of fuels are of great value to fuel engineer; ignition temperatures; numerical determination of heat of ignition; relation between chimney draft and forced draft; different types of grates are discussed with regard to their influence on ignition and combustion process; significance of catalysis.

FURNACES, INDUSTRIAL

Waste-Heat Utilization in. Umlauffeuerung Streifzeuge durch die in- und auslaendische Patentliteratur (Circulating System of Firing), K d'Huart. Waerme, vol. 54, nos. 7 and 8, Feb. 14, 1931, pp. 121–123 and Feb. 21, pp. 136–138, 14 figs. Review of international patent literature dealing with circulation or exhaust-gas return system of furnace firing; by this process part of exhaust gases, which have already been utilized and cooled off, are returned to furnace, in order to cool to required admission temperature fresh exhaust gases discharged from combustion chamber.

G

GALVANIZING

Centrifugal Process. Centrifugal Process Meets Demand for High-Quality Galvanizing—I. K. P. Rolston. Steel, vol. 88, no. 14, Apr. 2, 1931, pp. 39–42, 8 figs. Methods commonly used in handling small articles that have been hot-dip galvanized.

GASES

Flame Propagation in. La combustion et la détonation des mélanges gazeux les "antidétonants" (Combustion and Detonation of Gaseous Melanges, Anti-Knock Compounds), P. Laffitte. Société d'Encouragement—Bul., vol. 130, no 1, Jan. 1931, pp. 15–29. Ignition, combustion, and detonation; tables showing minimum and maximum limits of ignitability of air-gas mixtures; speed of propagation and expansion; phenomena of knock; explosion in pipes, mechanical means for damping of knock; anti-knock compounds. Bibliography.

GEARS

Design. Die Zulaessige Zahnradbeanspruchung und ihre Berechnungsweise im Werkzeugmaschinenbau (Permissible Gear Stresses and Their Calculation in Machine Tool Design), H. Hofer. Werkstattstechnik, no. 5, Mar. 1, 1931, pp. 128–131. Study of permissible stress in gears and related factors; formulas and experimental data sufficient for comprehensive investigation are represented in simple and practical form.

Grinding. Schleifen, Laeppen oder Einlaufen von Zahnraedern? (Grinding, Lapping, or Running in of Gears?), R. Hofmann. Maschinenbau, vol. 10, no. 5, Mar. 5, 1931, pp. 174–177, 28 figs. Investigation of principal gear-finishing methods with regard to relative accuracy; advantages of grinding by Maag grinding machines are illustrated by diagrams.

GRINDING MACHINES

Cam. New Cam Grinding Device of British Design. Machy. (N. Y.), vol. 37, no. 8, Apr. 1931, pp. 592–593, 3 figs. Design and operation of attachment patented by Churchill Machine Tool Co., Manchester, England, for use on either cam grinding or standard cylindrical grinding machines; constant angular velocity of cam being ground is obtained by combination lateral and parallel movement of fixture.

GRINDING WHEELS

Stresses in. Ueber den Spannungszustand in Schleifscheiben (Stresses in Grinding Wheels), C. Krug and H. Schlechtweg. V.D.I. Zeit., vol. 75, no. 10, Mar. 7, 1931, p. 300. Mathematical solution of problem of stresses in rotating disks in which expansions do not grow in proportion to stresses.

H

HEAT-ENGINEERING EXHIBITIONS

Leipzig. Waerme und Kraft auf der Grossen Technischen Messe Leipzig, 1931 (Heat and Power Exhibits at Technical Fair in Leipzig, 1931), Waerme, vol. 54, no. 9, Feb. 28, 1931, pp. 145–150, 9 figs. Review of exhibits of fuel, heat, and power group in Pavillion 21 under supervision of Verein Deutscher Maschinenbau-Anstalten, including measuring instruments, fittings, furnaces, air-heating and ventilating plants, internal-combustion engines, and packing materials.

HYDROELECTRIC POWER DEVELOPMENTS

Europe. European Hydro Practice Through American Eyes, L. F. Harza. Elec. World, vol. 97, no. 13, Mar. 28, 1931, pp. 588–592, 9 figs. Excerpts from notes offering comments on differences between our practices and those of old world; one thing that claims notice from American visitor is great amount of laboratory research on general problem of hydro power, conspicuous example being cavitation laboratories and their experiments performed in connection with all-important developments.

HYDROELECTRIC POWER PLANTS

Backwater Suppressors. An Investigation of the Back-Water Suppressor as Applied to a Hydroelectric Installation, A. H. Gibson. Instn. Civil Engrs.—Selected Eng. Papers, no. 92, 1930, 20 pp., 9 figs. Studies of models of various designs of backwater suppressors in Engineering Laboratories of Manchester University; formation of standing wave with no flow through draft tube; effect of depth of draft tube; theory of standing wave as applied to back-water suppressor; best form of suppressor is one in which bottom of tail race is raised above that of draft tube; for this type of installation performance can be predicted only from experiments with models.

France. Les usines hydro-électrique de Brommat et de Sarrans de la Société des forces motrices de la Truyere (Hydroelectric Power Plants of Brommat and Sarrans). Science et Industrie, vol. 15, nos. 204 and 205, Jan. 1931, pp. 2–13 and Feb. 1931, pp. 59–63, 17 figs. Program undertaken by Societe des Forces Motrices de a Truyere covers construction of underground Brommat power house design for power of 240,000 hp. to be fed by 7400 m. canal output of 84 cu. m. per sec. and construction at Sarrans of large dam 100 m. high giving total reserve of 3010 m. cu. m. and station designed for output of 120,000 hp. at its foot.

Pipe Lines. Design of Pipelines for Hydroelectric Plants, J. S. Carpenter. Power Plant Eng., vol. 35, no. 7, Apr. 1, 1931, pp. 418–419. To secure most economical design of pipe line for given condition, diameter, and thickness are figured by modification of Enger's formula.

Scotland. The Lochaber Power Plant. Elec. Rev., vol. 108, no. 2782, Mar. 20, 1931, p. 499, 2 figs. Station at Lochaber, near Fort William, Invernesshire, Scotland, is largest water-power undertaking in Great Britain; generating plant now installed comprises five main 9600-hp. d.c. sets driven by Pelton wheel-type turbines and are made by English Electric Co., Ltd., and two subsidiary turbo alternators of 1250-kw., each driven by Boving water-wheel turbines supplied by Metropolitan-Vickers Electrical Co.; five main sets develop power under minimum net head of 650 ft. and at minimum speed of 237 r.p.m.

I

IMPACT TESTING

Notched-Bar. The Effect of Rate of Bending in Notched-Bar Bending Tests, J. G. Docherty. Engineering, vol. 131, nos. 3400 and 3402, Mar. 13, 1931, pp. 347–350 and Mar. 27, pp. 414–415, 18 figs. Experiments undertaken to establish, if possible, relation between slow bend and Izod notched-bar test, and to discover if impactive nature of latter might account for discrepancies referred to.

INDUSTRIAL MANAGEMENT

Automobile Plants. Recent Developments in Works Management in the Automotive Field, J. Geschelin. Soc. Indus Engrs.—Bul., vol. 13, no. 2–3, Feb.-Mar. 1931, pp. 9–12. Budget control for non-production materials and other burden accounts; recent development in plant layout; wage incentives, particularly for indirect or non-production activities; scheduling and planning; inventory control.

Cost Accounting—Graphic Charts. Present Cost Facts Graphically, F. F. Hovey. Factory and Indus. Mgmt., vol. 81, no. 4, Apr. 1931, pp. 599–601 and 646, 6 figs. Use of graphic charts by Eastman Kodak Co., Rochester, N. Y., for presentation of fundamental relationship between unit costs and changing volume of production.

Piece Work. Akkordentlohnung und Zeitstudienverfahren (Piece Work Wage Payment and Time Study), H. Freund. Werkstattstechnik, vol. 25, no. 6, Mar. 15, 1931, pp. 159–161. Critical review of conventional time-study methods and modern methods for determining in fair way average production of workman.

Production Control. See FOUNDRY PRACTICE.

Profit Management. Minimum Cost vs. Maximum Profit, R. C. Davis. Factory and Indus. Magmt., vol. 81, no. 4, Apr. 1931, pp. 611–613 and 635–636, 1 fig. Effect of turnover on manufacturing profits; maximum-profit ordering quantity depends directly on minimum-cost ordering quantity, but may differ considerably from it; presents simple relationship by which maximum-profit ordering quantity can be determined directly.

Time Study. See FORGE SHOPS.

INDUSTRIAL PLANTS

Inspection. Maintaining Precision Through Close Inspection, C. A. Ziebarth. Iron Age, vol. 127, no. 13, Mar. 26, 1931, pp. 998–1003, 15 figs. Inspection methods and equipment at plant of Bell & Howell Co., Chicago manufacturer of professional and amateur moving-picture equipment; data on design and tolerances of various gages, particularly dial gages; standard blank forms of inspection report are illustrated.

Windowless. Why We Built A Windowless Factory, A. T. Simonds and G. K. Simonds. Brick and Clay Rec., vol. 78, no. 6, Mar. 24, 1931, pp. 314–315, 1 fig. Simonds Industries factory at Fitchburg, Mass., will replace three other plants; windows are sometimes more expensive to build than blank walls, they occupy valuable wall space, they increase heating cost, and their washing is expense; artificial light can be distributed evenly; it has been freed from glare; it can be given daylight color; it can include ultra-violet rays; through automatic humidity control, moisture content of air will be kept at point most beneficial to comfort and health.

INTERNAL-COMBUSTION ENGINES

Crankshafts. Un nouveau système de construction de vilebrequins démontables pour moteurs à explosion (New System of Constructing Multi-Piece Crankshaft for Internal-Combustion Engine). Pratique des Industries Mecaniques, vol. 13, no. 11, Feb. 1931, pp. 450–452, 4 figs. Design of crankshaft, system Hirth, permitting use of ball and roller bearings.

Detonation. Untersuchungen ueber das Klopfen von Vergasermotoren (Investigation Into Knocking of Carburetor Type of Engines), L. Auer. Forschungsheft, vol. 2, no. 340, Jan. 1931, 18 pp., 24 figs. Review of work of Ricardo and Midgley and others in same field; results of experiments made by author with aim of throwing light on causes of knocking and when it will take place in engine; new instrument designed for measuring force and determining time of shock caused by knocking relative to dead center of stroke; results arrived at are compared with those found by Brown and Watkins.

Efficiency. Aenderung des spezifischen Brennstoffverbrauchs mit der Belastung von Verbrennungsmotoren (Change in Specific Fuel Consumption With Load of Internal-Combustion Engines), A. Kossitzky. Archiv fuer Waermewirtschaft, vol. 12, no. 3, Mar. 1931, pp. 92–93, 2 figs. Specific fuel requirement is inversely proportional to economic efficiency; efficiency varies with load of engine; minimum specific fuel requirement corresponds to given excess-air coefficient.

Heavy-Oil. Moteur a explosion alimenté aux huiles lourdes (Internal Combustion Engine Operated by Heavy Oils), E. Marcotte. Revue des Combustibles Liquides, vol. 9, no. 82, Feb. 1931, pp. 75–80, 6 figs. Design and operation of oil engine with spark ignition developed by F. Rochefort; sketches illustrate details of valves and timing mechanism; advantages of system are low operating pressure, possibility of light construction and low fuel consumption, applicable to 2-cycle and 4-cycle engine

Waste-Heat Utilization. Waste Heat Recovery from Internal Combustion Engines, With Particular Reference to Marine Oil Engines, W. Gregson. Diesel Engine Users Assn., no. S98, for mtg. Dec. 12, 1930, pp. 1–14 and (discussion) 15–31, 10 figs.; see also Eng. and Boiler House Rev., vol. 44, no. 8, Feb. 1931, pp. 534, 536, 538 and 540, 3 figs. Recovery of heat ejected by cooling water and exhaust gases; test results and specific examples of waste-heat recovery from Diesel exhausts; design and operation of Diesel waste-heat boilers.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES, DIESEL ENGINES, OIL ENGINES].

L

LATHES

Automatic. A New Automatic Lathe. Automobile Engr., vol. 21, no. 278, Mar. 1931, pp. 107–108, 3 figs. Design and operation of single-spindle automatic machine with inclined spindle and 40-hp. electric motor, developed by Ludwig Loewe & Co. A. G., Berlin.

Multiple-Tool. Die Verwndung der Vielstahlbank im Allgemeinen Maschinenbau (Application of Multiple Tool Lathes in Manufacture of Machinery), K. Hegner. Werkstattstechnik, vol. 25, no. 5, Mar. 1, 1931, pp. 143–147, 14 figs. Advantages of multiple-tool operation in general machine-shop work with particular regard to mass production; sketches illustrate design of multiple-tool holders as used in machining of pulleys, flanges, spindles, and railroad buffers.

LIQUIDS

Atomization. The Mechanism of the Atomization of Liquids, R. A. Castleman, Jr. U. S. Bur. Standards—Jl. Research, vol. 6, no. 3, Mar. 1931, pp. 369–376, 5 figs. partly on supp. plates. Discussion of general problem and of some applications of phenomena of liquid atomization, with especial reference to fuel preparation in internal-combustion engines.

LOCOMOTIVES

Boilers, High-Pressure. Staybolting for High Pressure, C. M. Walsh. Boiler Maker, vol. 31, no. 3, Mar. 1931, pp. 73–74, 1 fig. Causes of crown-sheet failure; inspection, maintenance and repair of crown sheet; methods of forming hollow long stays.

Compound. Compound Locomotives of the P. L. M. Railway. Ry. Gaz., vol. 64, no. 9, Feb. 27, 1931, pp. 310–311. History of compound locomotive development on P. L. M. Railway; tabulated information relating to operating trials of single-expansion and compound locomotives. Before Inst. Locomotive Engrs.

Crankshafts—Welding. Arc Welding Broken Crank Shafts. Welding Engr., vol. 16, no. 3, Mar. 1931, pp. 36–38, 10 figs. Experiences in welding of three-cylinder locomotive crankshaft which broke across crank sheet and wrist pin; details of fracture and welding procedure are illustrated by sketches.

Diesel. Directly-Driven Diesel Locomotive, Italian State Rys. Locomotive, vol. 37, no. 463, Mar. 14, 1931, pp. 73–75, 2 figs. Transmission difficulties encountered in Diesel locomotive; development of design suitable for mixed traffic; Junkers-Diesel two-stroke engine, which combined qualities of simplicity, compactness, light weight, and remarkable range of useful speed; list of principal dimensions.

Feedwater Heaters. The New Gresham Feed-Water Heater for Locomotives. Ry. Gaz., vol. 54, no. 8, Feb. 20, 1931, p. 287, 1 fig. See also Ry. Engrs., vol. 52, no. 614, Mar. 1931, p. 92, 1 fig. Design and operating characteristics of feedwater heater fitted to L.N.E.R. high-pressure locomotive No. 10000 and numerous other engines.

Injectors. Abdampfvorwaermer und Abdampfinjektor (Exhaust Steam Preheater and Exhaust Steam Injectors), P. Juliusburger. Glasers Annalen, vol. 108, no. 4, Feb. 15, 1931, pp. 29–39, 22 figs. Report on experiences with exhaust injectors of various types and capacities; graphs illustrate comparison of performance economy with live steam and exhaust steam for different pressures and temperatures.

Internal-Combustion. The Industrial-Type Internal-Combustion-Engine Locomotive, S. B. Schenck. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Apr. 13–17, 1931, 5 pp., 10 figs. Advantages of gasoline, electric, and Diesel-electric drive places internal-combustion type ahead of steam locomotives with respect to availability for service, economy of operation, safety, visibility, convenience, and general performance; data on types built by H. K. Porter Co., Plymouth Locomotive Works, G. D. Whitcomb Co., Heisler Locomotive Works, Baldwin-Westinghouse and Differential Steel Car Co.

Passenger—Buenos Aires. New 4-6-2 Type Express Passenger Locomotive, Buenos Aires Great Southern Railway. Ry. Gaz., vol. 54, no. 10, Mar. 6, 1931, pp. 357–358, 1 fig.; see also Ry. Engr., vol. 52, no. 614, Mar. 1931, pp. 89–90, 1 fig. Design and constructional features of locomotives which have been built by Vulcan Foundry, Ltd., cylinders 19 by 26 in.; coupled wheels 6 ft. 6 in.; boiler pressure 200 lb. per sq. in.; tractive force 85 per cent; boiler pressure 30,685 lb.; total engine weight 86.2 tons; total engine wheelbase 33 ft. 6 in.

Testing. Neue Einrichtungen und Methoden zur wissenschaftlichen Untersuchung von Lokomotiven und ihren Einzelteilen (New Equipment and Methods for Scientific Research of Locomotives and Their Constituent Parts), K. Guenther and Solveen. Glasers Annalen, vol. 54, no. 5, Mar. 1, 1931, pp. 46–71, 49 figs. Schenck's weighing scale, test boilers, various small testing equipment; preparation of tests, locomotives for braking tests, selection of track, utilizing of test results; locomotives and rail motor car test stand and equipment.

LUBRICANTS

Cutting. Cutting Compounds Used by Ford, C. O. Herb. Machy. (N. Y.), vol. 37, no. 8, Apr. 1931, pp. 569–572, 4 figs. Preparation and composition of cutting compounds used in metal-working operations; soluble oil or "soda water" used for ordinary machine work; special compound for tapping and deep drawing; cutting oils for automatic screw machines and gear-cutting equipment; compound with unusually slippery qualities used for broaching and common drawing; methods of mixing compound; bacteriological tests determine when contents of shop pit must be discarded.

LUBRICATION

Graphite. Die praktische Bedeutung der Kollag-Schmierung (Practical Importance of Kolla Lubrication), H. Karplus. Maschinenbau, vol. 10, no. 6, Mar. 19, 1931, pp. 199–201, 2 figs. Report on experiments at University Karlsruhe show beneficial effect of colloidal graphite addition on properties of high-grade lubricants; advantages for high-speed bearings.

M

MACHINE-SHOP PRACTICE

Hole Spacing. Hole Spacing With a Microscope, W. C. Betz. Am. Mach., vol. 3, no. 24, Dec. 11, 1930, p. 931, 2 figs. Gives particulars of a practical method of using microscope in combination with set of size blocks to obtain center distances within tolerance of plus or minus 0.0002 in.

MACHINE TOOLS

Hydraulic Drive. Fluessigkeitsgetriebe fuer geradlinige Bewegungen an deutschen Werkzeugmaschinen (Hydraulic Drive for Straight Line Motion on German Machine Tools), E. Preger. V.D.I. Zeit., vol. 75, no. 10, Mar. 7, 1931, pp. 277–284, 41 figs. Relative merits and application of different type of drive and makes, including Oswald Forst, Solingen, Gustav Wagner, Reutlingen, Hille-Werke A.G. Dresden, Rein & Buelcker, Berlin-Halensee, J. E. Reinecker, A. G. Chemnitz, and other prominent concerns; application to grinding machine, planer, and drilling machine.

Manufacture. Putting the Finishing Touches on Machine Tools, D. Vande-Vate. Am. Mach., vol. 73, no. 24, Dec. 11, 1931, pp. 925–927, 4 figs. Painting and finishing operations and equipment of Gleason works, manufacture of bevel-gear cutting machinery; flow diagram illustrates routine of parts through painting operations.

Obsolescence. Controlling Factors in Machine-Tool Obsolescence, L. A. Blackburn. Soc. Automotive Engrs.—Jl., vol. 28, no. 4, Apr. 1931, pp. 463–469, and (discussion) 469–471, 2 figs. Examples are given of formulas or methods of determining economic advisability of purchasing new equipment, and their use is illustrated by being applied to set of assumed conditions by leaders of machine-tool industry, who advocated improved accounting procedure to give accurate costs; formulas for determining when to replace equipment.

The Machine Tool. Automobile Engr., vol. 21, no. 278, Mar. 1931, pp. 115–118, 2 figs. Analysis of factors determining obsolescence; particular regard to time element in production, effect of quantity and cost, comparison of machining costs for small machine parts on different types of machines with specific data for all cost items, output, etc.

Replacement. Evaluating Equipment Efficiency, K. H. Condit. Am. Mach., vol. 74, no. 9, Feb. 26, 1931, pp. 356–357, 2 figs. Blank forms illustrate efficiency record system in use by Bullard Company for purpose of determining whether to retain or replace production equipment.

MACHINERY EXHIBITIONS

Leipzig. The Leipzig Fair. Engineering, vol. 131, nos. 3399, 3400, Mar. 6, 1931, pp. 323–329, Mar. 13, pp. 354–357, 43 figs., partly on supp. plate. Review of some exhibits at Leipzig Spring Technical Fair; display is of thoroughly international character; 2327 manufacturers of machinery, tools, and other engineering equipment have taken space, and machine-tool industry alone is represented by 387 exhibits; some interesting developments and review of outstanding exhibits.

The Technical Fair at Leipzig. Engineer, vol. 151, nos. 3922 and 3923, Mar. 13, 1931, pp. 290–292 and Mar. 20, pp. 325–327, 26 figs. Leipzig Fair, which opened on Mar. 1, showed few signs of intense industrial depression which affects Germany in common with all manufacturing countries; display of machine tools organized by German Association of Machine Tool Makers is most striking section of exhibition; review of some outstanding exhibits.

MANGANESE STEEL

Welding. Welding High Manganese Steels. Welding, vol. 2, no. 3, Mar. 1931, pp. 169–171, 10 figs. Physical properties, preparation for welding and method of procedure, based on experiences of Fusion Welding Corporations; data on current densities and electrodes.

MATERIALS HANDLING

Equipment for. Etat actuel de la technique des appareils de levage et de manutention (Present State of Lifting and Conveying Equipment), A. Lambrette. Technique Moderne, vol. 23, no. 2, Jan. 15, 1931, pp. 35–72, 124 figs. Survey of all types of lifting and handling equipment, including block-and-tackle lift, winches, cranes, grab buckets for steam shovels and dredges; design of principal types of cranes, cable railroad and cableways, band conveyors, car dumpers, etc.

MATERIALS TESTING

Machine for. Lokale Festigkeitsbestimmung von Geweben, Wirkwaren, Papier, Kautschuk, Film, Holz, Leder, Metall und dergl. (Local Strength Testing of Woven Fabrics, Knit Fabrics, Paper, Rubber, Films, Wood, Leather, Metal, etc.), F. Schubert. Chemiker-Zeitung,

vol. 55, nos. 12 and 14, Feb. 11, 1931, pp. 113–114, and Feb. 18, pp. 134–135, 3 figs. Machine developed at Textile Research Institute of Vienna and manufactured by firm of Otto A. Ganser, for subjecting test sample to two-dimensional stress along its total perimeter; determination of absolute qualitative value of fiber in finished products; elongation tests; practical significance of process and its advantages.

METALS

Cold Rolling. Die Verfestigung einiger Werkstoffe beim Kaltwalzen (Strengthening of Some Metals With Cold Rolling), E. Greulich. Zeit. fuer Metallkunde, vol. 23, no. 3, Mar. 1931, pp. 91–94, 3 figs. Exponential law first derived for steels and monel metal is now confirmed for Armco iron, copper, and brass 70/30 up to rolling degrees of 30 per cent; strengthening factors for all these materials were calculated and used for analysis of composition and structure; pure metals, it was found, show less strengthening than alloys.

Deformation. The Deformation of Metals Under Prolonged Loadings—The Flow and Fracture of Aluminum—I. D. Hanson and M. A. Wheeler. Inst. Metals—Advance Paper, no. 554, for mtg. Mar. 11–12, 1931, 29 pp., 28 figs. Experimental work carried out with view to studying mechanism of flow and fracture under prolonged loads; authors' observations have bearing on theory of slip and rupture put forward by Gough, Hanson, and Wright.

Extrusion. The Influence of Pressure and Temperature on the Extrusion of Metals, C. E. Pearson and J. A. Smythe. Inst. Metals—Advance Paper, no. 558, for mtg. Mar. 11–12, 1931, 25 pp., 34 figs.; see also Metal Industry (Lond.), vol. 38, no. 12, Mar. 20, 1931, pp. 311–314, 20 figs. Experiments made in small press on extrusion phenomena of lead, cadmium, bismuth and tin; chief part of work is concerned with determination, under precise control of relationship between rate of extrusion, pressure, and temperature; relationship is expressed in series of curves, mathematical treatment of which is indicated.

Temperature Effect. Alloy Steels and Alloys for High-Temperature Service, L. W. Spring. Iron Age, vol. 127, no. 14, Apr. 2, 1931, pp. 1090–1093, 3 figs. Use of austenitic alloy steels, such as chrome-nickel and others, their advantages and disadvantages; requisites of metal for valves and valve seats; merits of non ferrous metals; success of nitralloy as new metal for seating valves.

High-Temperature Metals for the Power Plant, L. W. Spring. Iron Age, vol. 127, no. 13, Mar. 26, 1931, pp. 1004–1008, 2 figs. Review of progress in development of steel that will stand up under higher working temperatures and pressures, with particular regard to application in steam power plants and oil industry; author presents data on temperatures, pressures, and strength properties with particular regard to flow or creep.

MOLDING MACHINES

Jarring Machines. Die Ruettelformmaschine im Dienste des Schlepperbaues (Jar Molding Machines in Tractor Manufacture), K. Sipp. Werkstattstechnik, no. 5, Mar. 1, 1931, pp. 121–125, 5 figs. Review of machine molding methods and their application with particular regard to advantages of jarring machines and their economy in manufacture of tractors at plant of Heinrich Lanz A.G. Mannheim.

O

OIL ENGINES

Fuel Injection. The A.E.C. 95-Hp. High Speed Oil Engine. Motive Power, vol. 2, no. 2, Feb. 1931, pp. 16–17 and 42–43, 5 figs. Oil-engine design outcome of three years' development by Associated Equipment Co., Ltd., of Southall, Middlesex, England; operating characteristics of Acro fuel-injection system; 6-cylinder engine of 4.33 in. bore by 5.6 in. stroke with approximate displacement of 495 cu. in.; monobloc construction; test results; curves showing comparative fuel consumption of gasoline engine and A.E.C. oil engine; typical indicator diagram of high-speed oil engine.

OIL FUEL

Preheating. Preheating of Fuel Oil, K. Steiner and P. R. Unger. Heat, Piping and Air Conditioning, vol. 3, no. 4, Apr. 1931, pp. 297–303, 10 figs. Tabular classification of fuel oils according to Underwriters' Laboratories; reasons for preheating; typical heaters and methods of installation; electric heaters; economics of preheating; heat transfer rate diagram for fuel-oil heater.

P

PHOTOELECTRIC CELLS

Industrial Application. Photoelectric Tube Increasingly Applied in Industry, J. W. Marshall. Iron Age, vol. 127, no. 13, Mar. 26, 1931, pp. 1012–1013, and 1067–1068, 3 figs. Operation principles and industrial application including application to problem of packaging machine design.

PIPE

Cast-Iron—Centrifugal Casting. New Mono-Cast Centrifugal Pipe Plant, S. D. Moxley. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Apr. 20–23, 1931, 5 pp. Plant layout and production method with particular regard to operation of casting machines, sand handling, and conditioning equipment; plant of American Cast Iron Pipe Co. has capacity of 200 tons per shift.

Water, Heat Transmission in. Heat Transmission to Water Flowing in Pipes, A. E. Lawrence and T. K. Sherwood. Indus. and Eng. Chem., vol. 23, no. 3, Mar. 1931, pp. 301–309, 8 figs. Experiments were carried out on heating water flowing at 0.62 to 22.4 ft. per second through clean copper tube, 0.593 in. inside diam., by means of steam condensing from surrounding steam jacket; to determine effect of pipe length on film coefficient of heat flow from pipe to water, pipe length was varied from 59 to 224 diam. entire length of each tube being heated; average deviation of heat balance was less than 7 per cent.

PISTON RINGS

Casting. Piston Rings Cast by Centrifugal Process Have Close Grain and High Modulus of Elasticity, W. A. Oubridge. Automotive Industries, vol. 64, no. 13, Mar. 28, 1931, pp. 516–517, 5 figs. Manufacturing methods and equipment of British Piston Ring Co., Coventry, England, in making centrifugal casting for piston rings, cylinder liners, valve seats, and brake-drum liners.

Quality. Neue Untersuchungen ueber den Guetegrad von Kolbenringen in Abhaengigkeit vom Herstellungsverfahren (Effect of Manufacturing Process on Quality of Piston Rings), N. Stern. Automobiltechnische Zeit., vol. 34, no. 8, Mar. 20, 1931, pp. 177–181, 39 figs. Graphs illustrate radial pressure distribution for piston rings made in accordance with various manufacturing processes and subjected to different heat treatments; advantages of Ate-Ring.

PRESSES

Sheet-Metal-Working. Late Developments in Sheet-Metal Working Machinery, E. Marstaller. Eng. Progress, vol. 12, no. 2, Mar. 1931, pp. 55–58, 7 figs. Various types of machines developed by L. Schuler A. G. of Goeppingen illustrate progress in Germany; data on output and design of double-acting toggle drawing press with pneumatic die cushion; inclinable press with precision roll feed, aligning stock device, and scrap shear; output 170 feed motions per min.; can-making machines.

New Sheet-Metal Working Machinery at the Leipzig Fair, H. Birkle. Eng. Progress, vol. 12, no. 3, Mar. 1931, pp. 59–61, 6 figs. Design and operation of machines developed by Maschinenfabrik Weingarten vorm. hch. Schatz, Weingarten, Wuerttemzerg including 4 column crank press with built-in pneumatic die cushion of 1,000,000 lb. capacity and high-production machine for accurately straightening thin sheet metal.

PUMPING PLANTS

Detroit, Mich. Design Features of 90-ft. Circular Low-Lift Pumping Plant. Eng. News-Rec., vol. 106, no. 12, Mar. 19, 1931, pp. 468–472, 7 figs. Design and construction of substructure 108 ft. deep to house low-lift pumping equipment of Sprinkwells project of Detroit water department; annular well with overflow weirs provides for surge effects of 11-mi. supply tunnel; pumping units; consist of six 60 m.g.d. pumps, driven by synchronous motors, and two 30 m.g.d. pumps driven by slipring induction motors having normal speed of 500 r.p.m.; construction of station by caisson method; suction and discharge arrangement; design of interior.

PUMPS

Feedwater. Neuere Kesselspeiseanlagen (Modern Boiler-Feed Plants), R. Hanika. Waerme, vol. 54, no. 9, Feb. 28, 1931, pp. 160–164, 8 figs. Feedwater pumps of modern design; details of regulating system which automatically connects reserve turbine feedwater pumps, as soon as electric current fails or pressure in feed line sinks below permissible measure; automatic regulation of feedwater supply from lines with different pressures.

R

RAIL MOTOR CARS

Gasoline-Electric. Burlington Gas-Electric Cut Operating Costs. Ry. Age, vol. 90, no. 9, Feb. 28, 1931, pp. 439–443, 5 figs. 57 cars make 3,341,004 mi. in 1930, demonstrating 94.0 per cent availability and 36.3 per cent saving over steam-train service; possibilities of rail motor cars early appreciated; map showing wide distribution of gas-electric railcar operation on Burlington lines; general method of operation; performance table of 57 gas-electrics on Burlington in 1930; relatively few delays due to failures; organization chart for handling railcar inspection and maintenance.

RAILROAD ROLLING STOCK

Roller Bearings. Development of Roller Bearings on Steam Railway Equipment. Railroad Herald, vol. 35, no. 3, Feb. 1931, pp. 20–24. Brief historical review of plain bearing arrangement; operating characteristics of plain bearing; mechanical construction, method of application, lubrication methods, etc., of various types of railway equipment roller bearings; design features of following types of bearings: Fafnir-Melcher, S K F, Shafer, American Steel Foundries, Hyatt, and Timken. Before Lubrication Engrs.' Assn.

RAILROAD SIGNALS

Interlocking. New Control System Used at Electric Interlocking on the Burlington, W. F. Zane. Ry. Signaling, vol. 24, no. 3, Mar. 1931, pp. 81–84, 6 figs. Independent control and indication circuits make for simplicity, reliability, and freedom from grounds; signal layout plan; tower and power equipment at Downers Grove, Ill.; interlocking machine; outside construction, control, and indication circuits; locking and signal circuits.

RAILROAD TRAIN RESISTANCE

German Experiments on. Neue Versuche ueber den Fahrwinderstand von Personen und D-Zugwagen (New Experiments on Running Resistance of Passenger and Express Train Cars), Nocon. Glasers Annalen, vol. 54, no. 5, Mar. 1, 1931, pp. 99–121, 16 figs. Experimental trips of German Federal Railroads in order to determine influence of deadweight, design and length of train on running resistance with special regard to influence of side wind and overall performance for entire trains.

REAMERS

Tolerances. Practical Hole Tolerances, W. G. Holmes. Am. Mach., vol. 74, no. 9, Feb. 26, 1931, p. 349, 2 figs. Merits of system of hole, reamer, and plug gage tolerances adopted by General Motors with particular regard to practical operating advantages in connection with life of reamers.

REFRIGERATING PLANTS

Design. New Applications of Low-Temperature Freezing, F. Zumbro. Refrig. Eng., vol. 21, no. 4, Apr. 1931, pp. 259–264, 8 figs. Layout, equipment, design, and operation of recent installations of low-temperature refrigeration; layout of plant for freezing fruit in packages; refrigeration for peach freezing; quick hardening of ice cream.

ROLLING MILLS

Blooming Mills—Great Britain. The Toledo Steel Works, Sheffield. Engineering, vol. 131, no. 3402, Mar. 27, 1931, pp. 420–421; see also description in Engineer, vol. 151, no. 3924, Mar. 27, 1931, p. 356. New billet-rolling mill at Toledo Steel Works, Neepsend Lane, of Andrews Toledo Limited, comprises 25-in. three-high electrically operated mill driven by 750-h.hp. 3300-volt, three-phase induction motor; mill is fed by newly installed continuous ingot reheating furnace, also electrically operated.

Electric Equipment. Electric Rolling-Mill Equipment. Engineering, vol. 131, no. 3400, Mar. 13, 1931, p. 369, 2 figs. Installation constructed by English Electric Co., intended for operation of 27-in. three-stand reversing rolling mill at Brown, Bayley's steel works, Sheffield, includes in addition to motor, which replaces steam engine, flywheel motor-generator set and exciter set with necessary control and protective gear.

Non-Ferrous Metal. Die neuere Entwicklung der Walzwerke fuer Nichteisenmetalle (Modern Development of Rolling Mills for Non-Ferrous Metals), L. Weiss. Zeit. fuer Metallkunde, vol. 23, no. 3, Mar. 1931, pp. 73–76, 7 figs. Development of thin sheet rolling by use of multi-roll stands with small roll diameters, and its advantages; roll fractures; experiences with hardness of rolls.

Practice. Die Ursachen der Abhaengigkeit des Walzvorganges vom Walzendurchmesser (Relation Between Rolling Process and Roll Diameter), L. Weiss. Zeit. fuer Metallkunde, vol. 23, no. 2, Feb. 1931, pp. 47–51, 8 figs. Results of tests carried out by author on rolling of copper; difference between bearing losses in anti-friction and journal bearings in four-high mills; relation of static flow pressure to rolling pressure; approximate pressure distribution within deformation range; two- and three-stage rolling processes; superiority of anti-friction bearings over journal bearings and losses due to journal-bearing friction are demonstrated.

The Rolling Time of Merchant Mills, U. A. Peters. Rolling Mill Jl., vol. 5, no. 3, Mar. 1931, pp. 187–189, 2 figs. Method by which rolling times for various types of mills having same reductions may be compared.

Roll Design. Roll Pass Design, W. Trinks. Rolling Mill Jl., vol. 5, nos. 2 and 3, Feb. 1931, pp. 99–105, and Mar., pp. 181–186, 189, and 190. 10 figs. Feb.: Pass design and roll layout for rolls employed in three-high blooming mills and two-high tandem blooming mills. Mar.: Passes employed in blooming and billet-mill rolls; use of gothic passes, and details of their construction.

ROLLS

Cast-Iron. Die Herstellung von Gusseisen-Walzen (Manufacture of Cast-Iron Rolls), E. Peipers. Stahl und Eisen, vol. 51, no. 12, Mar. 19, 1931, pp. 345–350 and (discussion) 350–351, 4 figs. Manufacture and properties of loam and chill-cast rolls; Peipers process for manufacture of hard rolls, especially adaptable to thick plate rolls; Weymerskirch process; properties of rolls of alloyed metal, including those of Phoenix metal and adamite, employed extensively in America.

Hartgusswalzen, ihre Fehler und deren Ursachen (Chill Iron Rolls, Their Defects and Causes), W. Breitenbach. Giesserei, vol. 18, no. 10, Mar. 6, 1931, pp. 206–209. Causes of fractures and cracks and recommendations for treatment and reclamation.

S

SAWS

Metal-Cutting. Filing and Sawing Machines, W. L. Vogel. Eng. Progress, vol. 12, no. 3, Mar. 1931, pp. 61–62, 4 figs. Design and operation of combination filing and sawing machines built by Gebr. Thiel G.m.b.H., of Ruhla, Thuringia; time for die-making operations are reduced from 20 to 4 hr.

SCRAP METAL

Briquetting. Briquetting of Cast Iron Borings and Steel Turnings, A. K. Nowak. Iron Age, vol. 127, no. 14, Apr. 2, 1931, pp. 1097–1100, 3 figs. Data on price and output of scrap metal; design and operation of briquetting equipment which permits saving inherent value in machine-shop refuse materials, without undue oxidation in furnace; plan illustrates layout of plant for briquetting cast-iron borings and steel turnings, observations and tests of melting briquets in cupola.

Handling. Handling Thin Sheet Scrap in Tin Plate and Sheet Mills, H. H. Giles. Iron Age, vol. 127, no. 15, Apr. 9, 1931, pp. 1158–1163, 8 figs. Review of various methods and types of equipment including presses, elevators, and cranes with magnets; considerations in handling and pressing different types of scrap. Before Nat. Industrial Congress, Cleveland.

SCREW MACHINES

Rapid-Production. Machining Sixty-five Pieces per Minute, R. L. Bartlett. Machy. (N. Y.), vol. 37, no. 7, Mar. 1931, pp. 518–520, 6 figs. Design and operation of multiple-spindle screw machine equipped with non-indexing headstock and complete set of tools for each of four spindles; spindle speed 2400 r.p.m. and production 35,000 pieces per 9-hr. day.

SHEET METAL

Testing. Beitraege zum Hin- und Herbiegeversuch fuer duenne weiche Stahlbleche (Bending Test for Thin Soft Steel Sheets), J. C. Godsell. Stahl und Eisen, vol. 51, no. 10, Mar. 5, 1931, pp. 302–303, 1 fig. Simple and useful device, designed by Jenkins, for carrying out alternating bending test; results of tests with annealing tests at temperatures between 650 and 950 deg. cent.; annealing period of 5 to 90 min. was found to be practical. From Swansea Tech. College Met. Soc. 1930.

Ein neues Pruefverfahren fuer Feinbleche (New Method of Testing Thin Sheet Metal), E. Siebel. Zeit. fuer Metallkunde, vol. 23, no. 2, Feb. 1931, pp. 64–66, 4 figs. Review of series of papers by author and A. Pomp indexed in Engineering Index 1929 and 1930, describing deep-drawing widening test; description of Guilléry apparatus; deep drawing and elongation of brass, copper and aluminum; study of grain structure.

SMALL ARMS

Manufacture. Machining Operations on Rifle and Revolver Parts. Machy. (Lond.), vol. 37, no. 961, Mar. 12, 1931, pp. 761–773, 31 figs. Methods and equipment employed at Royal Small Arms factory, Enfield Lock, Middlesex; sketches illustrate various types of fixtures; gaging and inspection methods with data on tolerances.

SNOW PLOWS

Locomotive. A High-Powered Rotary Snow Plough. Ry. Engr., vol. 52, no. 614, Mar. 1931, pp. 90–91, 2 figs. Details of articulated steam-operated type of German design and construction, capable of advancing in freshly fallen snow of 10-ft. depth at 3 to 3¾ m.p.h.; list of principal dimensions.

SPRING STEEL

Properties. Fatigue Strength of Carbon and Alloy Steel Plates as Used for Laminated Springs, R. G. C. Batson and J. Bradley. Engineering, vol. 131, no. 3401, Mar. 20, 1931, pp. 405–406, 4 figs. Tests described were started in 1926 and undertaken in order to discover whether substantial improvement could be made in spring plates by grinding or polishing them so as to remove outer skin; later, when such improvement was found, tests were extended to obtain information on effect of heat treatment on fatigue strength, when such treatment was carried out either before or after machining surface of plates.

Testing. An Investigation of Steels for Aircraft Engine Valve Springs, A. Swan, H. Sutton and W. D. Douglas. Engineering, vol. 131, no. 3400, Mar. 13, 1931, pp. 374–376, 4 figs. Silico-manganese steel wire; decarburization; cold-drawn carbon-steel wire; specially prepared chrome-vanadium steel wire; results on Swedish wire; comparison with results of other investigators.

SOUND MEASUREMENT

Instrument for. Le mecascope (The Mecascope), Vassillière-Arlhac. Société Française des Electriciens—Bul., vol. 1, no. 2, Feb. 1931, pp. 148–153. Indicating and recording instrument used for auscultation of abnormal noises of mechanism in motion, developed by Vatinet and Durance, and taking place of telephone in sound-measurement circuits.

SPRINGS

Manufacture. Federnwindesmaschinen (Spring Winding Machine), O. C. Schmid. Werkstattstechnik, vol. 25, no. 5, Mar. 1, 1931, pp. 140–143, 19 figs. Design and operation of automatic winding machines for coil springs; methods of winding spring without mandrel.

STEAM

High-Pressure. L'emploi de la vapeur de'eau à haute pression et à température élevée (Use of High Pressure, High Temperature Steam), Nicolini. Science et Industrie, vol. 15, no. 205, Feb. 1931, pp. 55–58, 1 fig. Beginning of serial general account of question and causes of development of problem of high pressures and results obtained from industrial applications and from construction of material.

STEAM ACCUMULATORS

Constant-Pressure. Un type nouveau d'accumulateur de chaleur (New Type of Steam Accumulator), Marcheix. Science et Industrie, no. 204, Jan. 1931, pp. 29–33, 7 figs. Comparative study of steam accumulators of variable and constant pressure; advantages and operation of constant pressure accumulator, and its application in different industrial plants.

Ruths. The Ruths Accumulator Plant at Hattingen-on-Ruhr, H. Roentsch. Eng. Progress, vol. 12, no. 3, Mar. 1931, pp. 49–55, 12 figs. Design and operation of steam accumulator plant of Central Power Station at Hattingen-on-Ruhr; full load of 20,000 kw. can be sustained for 27 min. on accumulated steam, pressure falling from 185 to 70 lb. per sq. in.

STEAM-ELECTRIC POWER PLANTS

Belgium. The Langerbrugge Power Station in Belgium—I and II, D. Brownlie. Eng. and Boiler House Rev., vol. 44, nos. 8 and 9, Feb. 1931, pp. 492–495, and Mar., pp. 564–566 and 568, 3 figs. Feb.: Design, construction, and operating features of most advanced power station in world at Langerbrugge, near Ghent; boilers operating at 710 lb. per sq. in. pressure with superheated steam temperature 840 deg. fahr., driving 25,000-kw. back-pressure turbo-generators, exhausting at 285 lb. per sq. in. to condensing steam turbines; operating results of Benson steam generator. Mar.: Boiler design and operation; pulverized-fuel equipment; Salerni process of coal carburization.

STEAM ENGINES

Efficiency. L'influence de la surchauffe intermédiaire sur l'économie des installations motrices à vapuer (Effect of Intermediate Super-Heating on Economy of Steam Power Plants), C. Colombi. Chaleur et Industrie, vol. 12, no. 130, Feb. 1931, pp. 61–67, 3 figs. Investigation of thermodynamic efficiency of installation with and without intermediate superheating; graph illustrates specific-heat consumption and function of pressure and enthalpy of intermediate superheating.

Valves and Valve Gears. Nachfuellschieber (Auxiliary Valves), F. Meineke. Glasers Annalen, vol. 108, no. 4, Feb. 15, 1931, pp. 39–41, 5 figs. Methods of increasing valve opening period without increase in stroke; operating principles and design of auxiliary valves which admit steam from 55 to 86 per cent of this stroke, according to American practice on locomotives.

STEAM HEATING

Direct Radiation. Investigation of Various Factors Affecting the Heating of Rooms With Direct Steam Radiators, A. C. Willard, A. P. Kratz, M. K. Fahnestock, and S. Konzo. Univ. Ill.—Eng. Experiment Station—Bul., no. 223, vol. 29, no. 31, Mar. 31, 1931, 104 pp., 51 figs. Study was made of surface temperatures and temperature gradients through walls and glass; tests to determine effect of various factors encountered in actual heating practice on heating of typical room by means of cast-iron steam radiators.

STEAM PIPE LINES

Calculation. Le calcul des tuyauteries de vapeur (Calculation of Steam Pipe Line), R. Jumentier. Pratique des Industries Mecaniques, vol. 13, no. 12, Mar. 1931, pp. 505–511, 4 figs. Practical calculations relating to most common problem in design of steam pipe lines such as pressure drop, effect of elbows, valves, etc.; variations in velocity due to throttling.

High-Temperature. Piping for 1000-Degree Steam, J. H. Walker. Heat., Piping and Air Conditioning, vol. 3, no. 4, Apr. 1931, pp. 283–287, 5 figs. Design and construction features of piping system which will convey steam at temperature of 1000 deg. fahr. from superheaters to turbines installed at Delray power plant of Detroit Edison Co.; details of 10,000-kw. turbine; provisions for thermal expansion; composition table of principal materials used in piping installation.

Welding. Flanschenlose Heissdampfleitungen (Flangeless Superheated-Steam Pipe Lines), K. Karnath. Waerme, vol. 54, no. 8, Feb. 21, 1931, pp. 129–131, 7 figs. Many years of experience have demonstrated that superheated-steam lines for high pressures as well as valves and fittings can be welded together or welded into pipe lines without flanges, and by this means considerable economies can be effected.

STEAM POWER PLANTS

Back-Pressure. Die Wahl des richtigen Gegendrucks (Choice of Proper Back Pressure), K. Lapp. Archiv fuer Waermewirtschaft, vol. 12, no. 3, Feb. 1931, pp. 55–57, 2 figs. Lowering of pressure in back-pressure stage is thermodynamically equivalent to increasing pressure in power stage; economic superiority of first measure is demonstrated; choice of proper back pressure is facilitated by use of diagrams presented; application to briquet factory.

Pulverized-Lignite. Das Braunkohlen-Kraftwerk Mydlovary (Mydlovary Lignite Power Plant in Czechoslovakia), F. Wiesner. Archiv fuer Waermewirtschaft, vol. 12, no. 2, Feb. 1931, pp. 33–37, 3 figs. Steam-electric power plant burning lignite from Southern Czechoslovakia; preparation of pulverized lignite; boiler-house equipment; operating experiences and results.

STEAM TURBINES

Efficiency. Die Grenzleistung von Dampfturbinen (Efficiency Limit of Steam Turbines), H. Kluge. Archiv fuer Waermewirtschaft, vol. 12, no. 2, Feb. 1931, pp. 49–54, 13 figs. Definition of efficiency limit; thermodynamic limit of efficiency; limit of blades and of disk diameter; chart of limit outputs is presented.

Kritik der Dampfverbrauchszahlen und Wirkungsgrade von Dampfturbinen (Steam-Consumption Coefficients and Efficiency of Steam Turbines), A. Renfordt. Waerme, vol. 54, no. 9, Feb. 28, 1931, pp. 151–155. Comparison of published steam-consumption coefficients with axial and radial turbines; condensation, back-pressure, and bleeder turbines.

United States. Betriebserfahrungen mit